Radiological Health Data and Reports

VOLUME 8, NUMBER 6
June 1967
(Pages 301-354)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 6, June 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

***Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.**

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

CONTENTS

REPORTS

	Page
Fallout from the Third Chinese Nuclear Test May 9, 1966 *R. D. Grundy* and *D. R. Snavely*	301

DATA

SECTION I. MILK AND FOOD	317
National and International Milk Surveillance	318
1. Pasteurized Milk Network, February 1967, *PHS*	318
2. Canadian Milk Network, February 1967	321
3. Pan American Milk Sampling Program, February 1967, *PAHO* and *PHS*	322
State Milk Surveillance Activities	323
1. California Milk Network, October–December 1966	323
2. Oregon Milk Network, October–December 1966	325
3. Washington Milk Network, October–December 1966	326
Food and Diet Surveillance Activities	328
1. Strontium-90 in Tri-City Diets, May–June 1966, *HASL*	329

CONTENTS—continued

	Page
SECTION II. WATER	331
Gross Radioactivity in Surface Waters of the United States December 1966, *FWPCA*	332
Radiostrontium in Tap Water, March–November 1966, *HASL*	334
Radioactivity in California Waters, January–June 1966	335
SECTION III. AIR AND DEPOSITION	339
Radioactivity in Airborne Particulates and Precipitation	339
1. Radiation Surveillance Network, February 1967, *PHS*	340
2. Canadian Air and Precipitation Monitoring Program, February 1967	343
3. Mexican Air Monitoring Program, February 1967	344
4. Pan American Air Sampling Program, February 1967, *PAHO* and *PHS*	345
SECTION IV. OTHER DATA	347
Environmental Levels of Radioactivity at Atomic Energy Commission Installations	347
1. Brookhaven National Laboratory, July–December and annual Summary 1966	347
2. Lawrence Radiation Laboratory, January–June 1966	349
SECTION V. TECHNICAL NOTES	353
Status of Full Scale Strontium-90 Removal System for Fluid Milk, *NCRH*	353
Reported Nuclear Detonations, May 1967	354
Synopses	iii
Symbols, Units, and Equivalents	Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
National Center for Radiological Health
Donald L. Snow, Chief

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

Reports

Fallout from the Third Chinese Nuclear Test—May 9, 1966

R. D. Grundy [1] and *D. R. Snavely* [2]

Fresh fission product debris was detected in the United States in selected environmental media following the third Chinese atmospheric nuclear detonation of May 9, 1966. Peak concentrations in air, precipitation deposition, bovine thyroids, and milk, occurred in the Central and Southern States. Levels of iodine–131 in milk as observed by 4 State sampling programs and 18 U.S. Public Health Service Pasteurized Milk Network stations provided the basis for calculating iodine–131 pasture weathering half-times of 4 to 58 days. A peak iodine–131 milk concentration of 920 pCi/liter was observed in Arkansas on May 21, 1966. The resultant cumulative iodine–131 intake at this location based upon an assumed daily milk consumption of 1 liter, was calculated to correspond to 1.7 percent of the Protective Action Guide as established by the Federal Radiation Council.

Summary of surveillance data

On May 9, 1966, a third nuclear detonation occurred on the mainland of China (*1*). The test was believed to have taken place in northwest China and was equal to or greater in total yield, expressed as an equivalent force of TNT, than the earlier two detonations (October 16, 1964 (*2*) and May 14, 1965 (*3*)). Subsequent to this test, fresh fission products were observed in the United States [3] by Federal and State environmental monitoring systems. This report summarizes the extent and magnitude of the intrusion of fresh fission products into the environment during May and June 1966, as indicated by State milk sampling systems and the Radiation Surveillance Network (*4–7*), Pasteurized Milk Network (*8–9*), and the Bovine Thyroid Network (*10*) of the U.S. Public Health Service.

[1] Mr. Grundy was formerly chief, Data Analysis and Operations Section, Standards and Intelligence Branch, NCRH, Washington, D.C.

[2] Mr. Snavely is operations officer, Data Analysis and Operations Section, Standards and Intelligence Branch, NCRH, Washington, D.C.

[3] Defined in this report as the original 48 States.

Intrusion pattern

In all but 6 cases out of 74 the April 1966 maximum daily gross beta radioactivity concentration for a station was less than twice the monthly average. The April 1966 averages (*11*) ranged from 0.10 to 0.26 pCi/m^3 (except for Cheyenne, Wyo., which was 0.76 pCi/m^3).

In view of the relatively constant concentrations of beta radioactivity in air that existed immediately prior to the detonation, it was assumed that the presence of fresh fission products at a given Radiation Surveillance Network (RSN) station was indicated by a daily air gross beta radioactivity concentration greater than twice the previous month's (April 1966) average for that station (*11*).

On the above basis, fresh fission products were first detected in surface air at two RSN stations on samples collected May 13–14, 1966, (approximately 5 days after the detonation). The stations were Denver, Colo., and Boise, Idaho, and the gross beta radioactivity concentrations were 3.3 and 2.4 pCi/m^3, respectively.

Immediately preceding this detonation all precipitation samples showed gross beta radio-

activity concentrations less than 200 pCi/liter. Similarly, precipitation samples with gross beta radioactivity concentrations greater than 200 pCi/liter were considered indicative of the presence of fresh fission products.

Using the results of the air and precipitation measurements, it was possible to approximate the intrusion pattern of fresh fission product debris in surface air across the United States. The indicated pattern (figure 1) is only a general approximation of what occurred, and is not intended to define the extent of lateral spread of the debris cloud, since uncertainties in the data are too great for anything but general approximations. The indicated dates represent a 24-hour collection period from 8 a.m. the first day to 8 a.m. the following day.

Following the initial appearance of fresh fission products on May 13–14, the debris cloud proceeded across the Western Plain States on May 14–15, centered over the Midwest on May 15–16, and passed over the South and East on May 16–17. In this period (May and June 1966) the maximum RSN air gross beta radioactivity concentration was 14.9 pCi/m^3 at Phoenix, Ariz., on May 19–20, 1966.

It should be noted that all RSN air gross beta radioactivity concentrations greater than 10 pCi/m^3 (six samples) occurred in the West and Southwest between May 14 and 26, 1966. In general, these activities occurred 5 to 6 days after the passage of the leading edge of the surface air debris cloud. This time lag is comparable with results observed for the second Chinese mainland test (*12*).

Air

An effort was made to evaluate the extent and magnitude of the intrusion of fresh fission product debris. It was shown that as the peak air gross beta radioactivity concentrations increased with time, the percent of the RSN stations showing concentrations greater than 1.0 pCi/m^3 increased. The relative magnitude of the intrusion was then evaluated on a regional basis in terms of the percentage of RSN stations with gross beta radioactivity concentrations in air greater than 1.0 pCi/m^3.

Regional grouping of the data on a semiweekly basis (Sunday through Wednesday and Thursday through Saturday) are given in table 1. A maximum of 80 percent was observed in Region VIII for the period May 26 through May

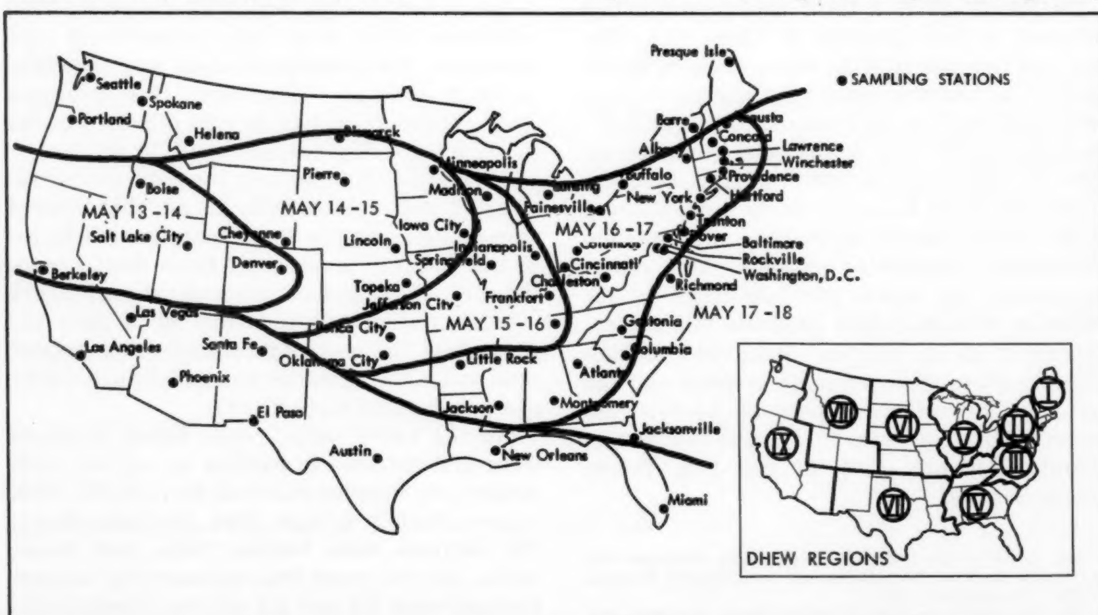

Figure 1. Approximate intrusion pattern of the fresh fission product debris cloud across the United States from the third Chinese nuclear detonation as indicated by the RSN

Table 1. Percentage of daily RSN air filters with gross beta radioactivity greater than 1 pCi/m³

Region [a]	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Region II	0	0	0	6	0	17	0	0	0	0	0	0	0	0	0
Region III	0	0	0	10	11	29	0	0	0	0	0	0	0	0	0
Region IV	0	0	6	42	55	17	17	0	4	0	0	0	0	0	0
Region V	0	0	14	10	11	0	0	0	0	0	3	0	0	0	0
Region VI	0	0	11	10	19	0	0	0	0	5	0	0	0	0	0
Region VII	0	0	7	43	62	19	14	5	26	4	8	0	4	0	0
Region VIII	0	13	10	47	25	80	37	47	20	20	0	0	0	0	0
Region IX	0	0	0	33	29	43	21	15	0	5	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawaii	0	0	0	0	75	33	0	0	0	0	0	0	0	0	0

[a] For identification of States within Region, see insert, figure 1.

28. These data indicate that the extent and relative magnitude of the intrusion of fresh fission products were greatest in Regions IV, VII, VIII, and IX. These regions represent the Southern, South Central, Western and Far Western United States, respectively.

Precipitation

Gross beta radioactivity concentrations in RSN precipitation samples were observed to increase sharply during the latter part of May 1966. Prior to this time (April 1966), precipitation activities were, in general, below the minimum detectable concentration of 200 pCi/liter (*11*). An effort was made to evaluate the geographic extent of the deposition of fission product debris by precipitation in terms of the percentage of the precipitation samples exhibiting gross beta radioactivity concentrations greater than 200 pCi/liter. These data are given in table 2. The regional grouping of the data on a semiweekly basis indicates that the extent of the deposition of fresh fission product debris by precipitation was greatest in the Far Western, Western and Southern United States.

The magnitude of deposition resulting from precipitation was evaluated on the basis of RSN results (*4–7*). Depositions of gross beta radioactivity greater than 10 nCi/m² are summarized on a semiweekly basis in table 3. From the isograms of total gross beta radioactivity depositions from May 15 to 28 (figure 2), it is readily apparent that the Central United States received the greatest depositions. From table 3, it is seen that these occurred between May 15 and 25, immediately following the passage of the debris cloud across this area as indicated by the RSN surface air measurements (figure 1).

Table 2. Percentage of RSN precipitation samples with gross beta radioactivity greater than 200 pCi/liter

Region [a]	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I	12	0	0	58	75	25	0	50	71	20	33	25	50	20	40
Region II	0	0	0	75	55	100	60	NS	100	33	0	0	33	NS	0
Region III	0	0	33	100	80	57	63	NS	50	43	0	17	0	NS	20
Region IV	0	0	78	100	93	100	83	0	40	25	33	0	0	33	40
Region V	0	0	88	100	80	NS	100	0	60	17	75	0	NS	NS	20
Region VI	11	0	86	80	100	NS	100	100	90	25	60	75	100	0	25
Region VII	0	0	55	40	100	0	100	100	100	NS	75	17	60	0	14
Region VIII	0	0	0	NS	NS	NS	100	100	75	67	NS	75	100	50	100
Region IX	0	0	0	NS	0	50	100	75	50	33	0	NS	NS	25	33
Alaska	0	0	0	0	0	0	33	0	NS	NS	0	0	0	NS	0
Hawaii	NS	NS	NS	0	NS	NS	0	NS	NS	NS	NS	NS	NS	NS	NS

[a] For identification of States within Region, see insert, figure 1.
NS, no sample collected.

Figure 2. Total deposition of gross beta radioactivity in nCi/m² as observed in RSN precipitation samples (May 15 through May 28, 1966)

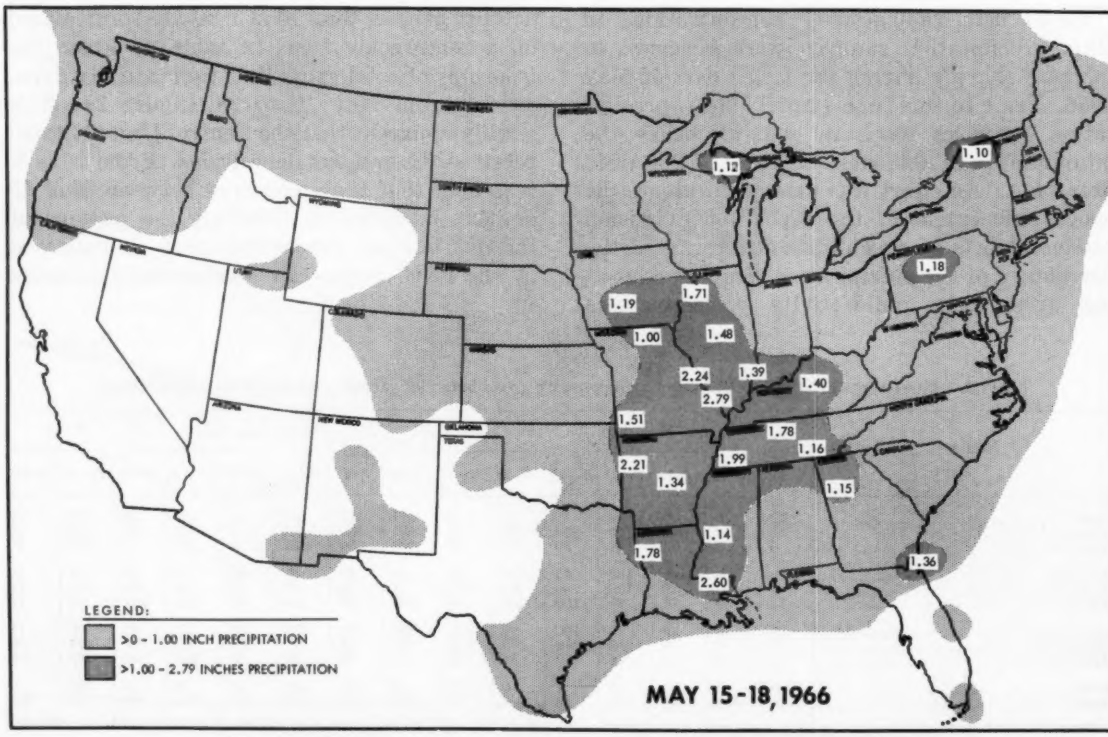

Figure 3. Total precipitation occurring between May 15 and 18, 1966 (*13*)

Table 3. Semiweekly wet deposition of gross beta radioactivity greater than 10 nCi/m^2

Region and States	Deposition (nCi/m^2)														
	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I															
Maine				85.2											
Region II															
Region III															
District of Columbia				13.5											
Kentucky			41.7												
North Carolina			91.8												
Region IV															
Alabama															13.1
Florida:															
Jacksonville			36.0	10.1	151	19.9				13.6			13.9		
Miami					27.8		16.3		12.5						
Mississippi				38.9	29.6										
South Carolina					16.4					14.9			17.0		
Tennessee			72.8												
Region V															
Illinois			256												
Indiana			102												
Michigan			11.1							10.1					
Ohio: Columbus					13.9										
Wisconsin					36.4										
Region VI															
Iowa			11.2		13.7				13.1						
Kansas											21.5				
Minnesota					57.5			17.9							
Missouri			459	18.6	88.8										?
Nebraska				33.5	57.1										
North Dakota														11.4	
Region VII															
Louisiana				47.7											
Oklahoma:															
Oklahoma City				50.7											
Ponca City			12.9												
Region VIII															
Wyoming									30.6						
Region IX															

Additional isolated cases of deposition, approaching the levels observed in the Midwest, occurred in Augusta, Maine; Gastonia, N.C.; and Jacksonville, Fla.

Comparison of gross beta radioactivity deposition with total rainfall measurements obtained from the Weather Bureau (*13*) for the period of May 15 through 25, 1966, show good correlation. For the period of May 15 through 18, rainfalls were greatest in the Mississippi Valley States (figure 3), which coincides with the areas of greatest radioactivity deposition. Similar correlations are observed between rainfall and total deposition for the periods of May 19 through 21 (figure 4), and May 22 through 25 (figure 5).

The RSN gross beta radioactivity measurements of air, precipitation and total wet deposition have provided a basis for evaluating the extent and magnitude of the intrusion of fresh fission products into the environment. While the first indication of fresh fission product debris was observed by the RSN air and precipitation measurements, evidence of iodine–131 entrance into the food chain of man was reflected in bovine thyroids collected by the Bovine Thyroid Network (BTN), and in milk collected by the Pasteurized Milk Network (PMN).

Bovine thyroids

During May and June 1966, iodine–131 was found in bovine thyroids in measurable quantities at all collection areas (*10*). Although the collection areas were not uniformly distributed throughout the United States, analysis of

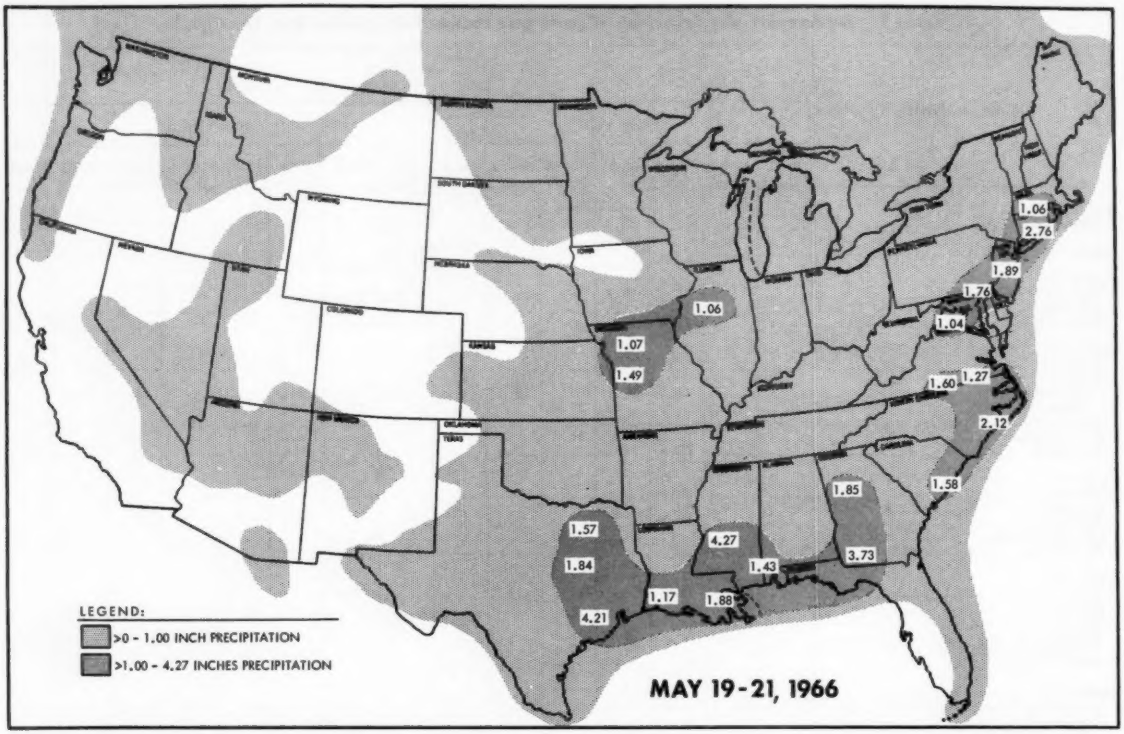

Figure 4. Total precipitation occurring between May 19 and 21, 1966 (*13*)

bovine thyroids served as an extremely sensitive method for the detection of iodine–131. While not as quick in its response as the determination of gross beta radioactivity levels in surface air, the BTN is specific for this radionuclide. It should be noted that although the thyroid sampling areas overlap the milksheds serving the metropolitan areas participating in the Pasteurized Milk Network (*12*) the selection of thyroid collection locations was based upon proximity to major nuclear reactors, spent-fuel reprocessing plants, and nuclear testing sites, not major population groups.

Because of the relatively small number of thyroids collected on any one day in a single area, it is difficult to relate the levels of iodine–131 in the bovine thyroid to the changing radioactivity levels in other environmental media. However, when the data were grouped on a regional basis, general trends for the influx of iodine–131 into the environment were seen.

Efforts were made to evaluate the extent of iodine–131 intrusion into the environment in terms of bovine thyroid results by grouping samples on a semiweekly basis. The percentages of samples exhibiting iodine–131 concentrations greater than 10 pCi/g of thyroid were then determined (table 4). Although the number of samples is limited, generally the findings show a geographical distribution similar to those observed for RSN air and deposition results (see tables 1, 3, and 4).

The magnitude of the intrusion can only be determined in a relative manner since for the areas receiving the highest fallout deposition (figure 2), the number of samples was small. The highest individual thyroid iodine–131 concentrations were 880 pCi/g on June 1 in Mississippi, and 880 pCi/g on June 7 in Colorado. The maximum semiweekly average was 530 pCi/g for June 5 through 8 in Region VII (New Mexico).

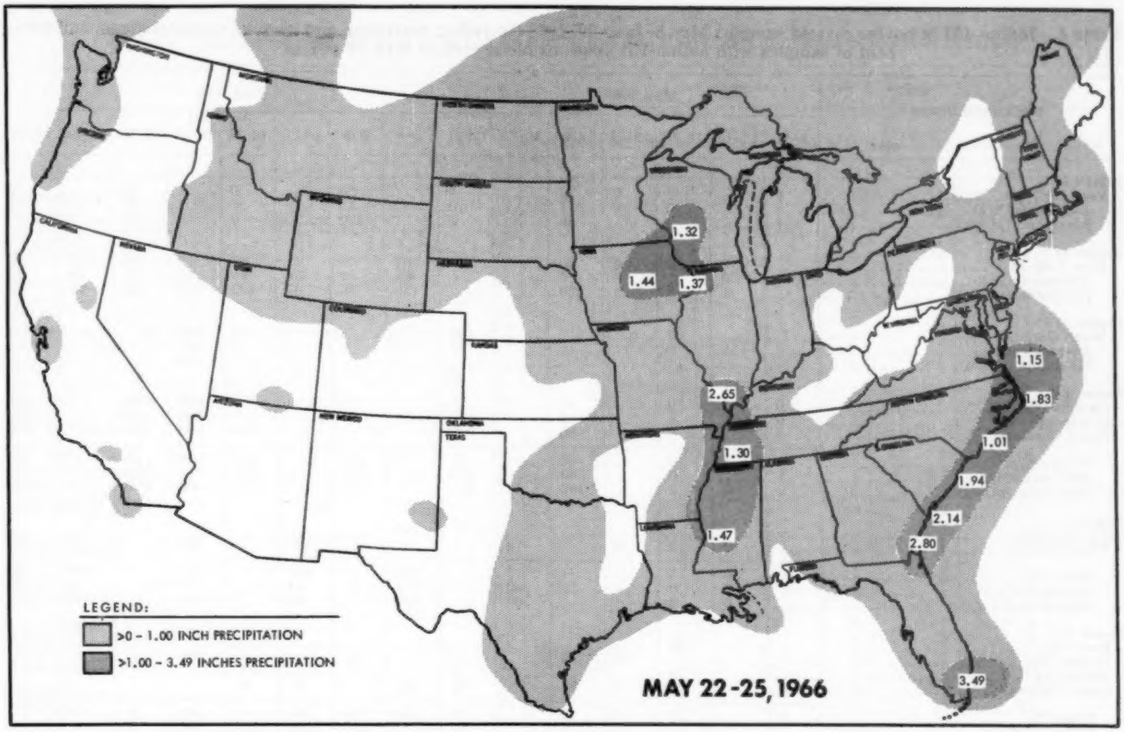

Figure 5. Total precipitation occurring between May 22 and 25, 1966 (*13*)

In the geographical area where gross beta radioactivity deposition was greater than 100 nCi/m^2 (figure 2), the number of bovine thyroid samples collected for this period (May and June 1966) was small. However, results from Region IV (Georgia, Mississippi, and South Carolina) indicated a sharp rise in iodine–131 activity around May 20 (figure 6), that reached a maximum semiweekly average of 400 pCi/g, followed by decay characteristic of a single deposition event. Similar results were observed (table 4) for Region VII (New Mexico).

Although data on the levels of iodine–131 in bovine thyroids were limited, it is evident that an increase in air radioactivity preceded the detection of iodine–131 in the thyroids, with both media clearly delineating the intrusion.

Milk

Following the third Chinese atmospheric nuclear test, the PHS Pasteurized Milk Network (PMN), and 31 State milk sampling networks (table 5), monitored iodine–131 concentrations in milk at an increased sampling frequency. For the period of May and June 1966, the sampling frequency for the PMN was increased to twice a week so as to provide greater coverage. The first appearance of iodine–131 in milk (20 pCi/liter or greater) occurred in those samples collected between May 15 and 18, at four locations. On May 16, iodine–131 in milk was reported by the State of Iowa at a concentration of 20 pCi/liter; however, it was not reported as present (greater than 10 pCi/liter) in a PMN sample collected on May 16 at Iowa City. The second appearance of iodine–131 in milk

Table 4. Iodine-131 in bovine thyroid samples May 8–June 29, 1966 (including maximum and average concentrations, and percent of samples with iodine-131 concentrations greater than 10 pCi/g)

Region and States [a]	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I															
Vermont (%)	0	------	0	0	30	------	0	------	60	------	0	------	70	------	0
Average (pCi/g)	1	------	0	0	11	------	0	------	53	------	0	------	23	------	1
Maximum (pCi/g)	1	------	0	------	48	------	1	------	120	------	0	------	94	------	0
Region II															
New York (%)	------	0	0	0	50	------	------	61	60	71	67	77	90	75	80
Average (pCi/g)	------	0	1	0	66	------	------	29	39	33	54	41	50	28	20
Maximum (pCi/g)	------	1	3	2	260	------	------	120	95	67	120	130	83	45	39
Region III															
North Carolina (%)	------	------	33	------	------	------	100	------	------	------	------	100	------	------	------
Average (pCi/g)	------	------	6	------	------	------	48	------	------	------	------	123	------	------	------
Maximum (pCi/g)	------	------	11	------	------	------	------	------	------	------	------	280	------	------	------
Region IV															
Georgia (%)	0	------	0	------	40	------	71	------			100	100	100		83
Mississippi (%)	0	------	0	------	33	------	100	------	100	------	------	100	80	------	100
South Carolina (%)	0	------	------	------	80	------	100	------	------	------	100	100	100	------	100
Total (%)	0	------	0	------	50	------	93	------	100	------	100	100	93	------	93
Average (pCi/g)	1	------	0	------	43	------	410	------	210	------	240	210	110	------	91
Maximum (pCi/g)	2	------	1	------	150	------	880	------	330	------	590	700	280	------	280
Region V															
Illinois (%)	------	------	------	------	------	------	------	100	------	------	------	------	------	------	------
Wisconsin (%)	------	0	0	0	------	71	------	------	------	100	------	100	------	50	80
Total (%)	------	0	0	0	------	71	------	100	------	100	------	100	------	50	80
Average (pCi/g)	------	0	0	4	------	93	------	410	------	19	------	49	------	9	25
Maximum (pCi/g)	------	0	0	6	------	200	------	560	------	24	------	53	------	12	48
Region VI															
Iowa (%)	------	------	100	------	------	------	------	------	------	------	------	------	------	------	------
Kansas (%)	------	------	------	33	0	------	------	------	100	------	------	100	0	------	------
Minnesota (%)	------	------	0	------	------	------	0	------	------	------	------	------	------	------	------
South Dakota (%)	0	------	0	0	33	------	60	100	------	83	83	------	------	------	------
Total (%)	0	------	33	14	29	------	43	100	100	83	83	100	0	------	------
Average (pCi/g)	2	------	11	5	5	------	62	170	210	240	450	40	9	------	------
Maximum (pCi/g)	4	------	20	21	11	------	260	280	210	640	814	49	9	------	------
Region VII															
Arkansas (%)	------	0	------	------	------	------	------	------	------	------	------	------	------	------	------
New Mexico (%)	13	------	38	------	100	------	100	------	100	------	100	88	75	------	------
Oklahoma (%)	0	0	------	------	------	------	------	------	------	------	------	------	------	------	------
Texas (%)	0	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Total (%)	7	0	38	------	100	------	100	------	100	------	100	88	75	------	------
Average (pCi/g)	6	3	8	------	17	------	200	------	530	------	510	100	39	------	------
Maximum (pCi/g)	17	7	15	------	25	------	250	------	760	------	790	210	97	------	------
Region VIII															
Colorado (%)	------	------	------	------	75	------	50	------	100	------	------	------	0	------	------
Idaho (%)	------	------	------	------	------	0	------	------	0	100	100	100	83	------	------
Utah (%)	------	------	------	------	------	67	40	------	50	------	75	------	------	80	25
Total (%)	------	------	------	------	75	60	44	------	67	100	78	100	71	80	25
Average (pCi/g)	------	------	------	------	29	63	61	------	220	37	78	95	55	35	21
Maximum (pCi/g)	------	------	------	------	55	460	330	------	880	89	240	120	100	74	55
Region IX															
California (%)	0	0	17	0	32	0	14	0	7	50	33	50	44	0	22
Washington (%)	------	------	------	------	------	------	25	------	93	------	------	------	------	------	------
Total (%)	0	0	17	0	32	0	19	0	33	50	33	50	44	0	22
Average (pCi/g)	1	0	6	8	11	6	11	2	16	9	8	10	23	4	11
Maximum (pCi/g)	2	1	17	6	54	9	95	3	93	17	25	24	110	9	44

[a] For identification of States within Region, see insert, figure 1.

was observed by the State of Arkansas on May 17 with a concentration of 160 pCi/liter. Although one must consider variations in the delay between milking and sample collection, a PMN sample collected 1 day earlier (May 16) showed less than 10 pCi/liter. Iodine–131 was first detected in Kentucky by the PMN on May 18 in two samples with concentrations of 20 and 30 pCi/liter. Apparent differences in the initial appearance of iodine–131 in milk between the PMN and State programs may be attributed in part to variations in sampling procedures, especially geographical and time factors. Variations due to feeding practices are assumed to be minimal for this period when dairy cattle can be expected to be on pasture

Table 5. Number of milk samples collected by States and the PMN, and minimum detectable activities

Network	Minimum detectable activities iodine-131 (pCi/liter)	Number of samples collected						
		May 15–21	May 22–28	May 29–June 4	June 5–11	June 12–18	June 19–25	Total
Alabama	10	----	----	----	----	----	----	NA
Arkansas	7	17	24	13	10	3	----	67
California	5	8	17	12	1	----	----	38
Colorado	10	13	----	----	2	1	1	17
Connecticut	8	2	2	2	2	2	2	12
Florida	20	2	3	2	4	5	2	18
Hawaii	----	----	----	----	----	----	----	NS
Idaho	50	1	1	1	1	1	1	6
Indiana	5	5	7	7	5	5	5	34
Iowa	5	5	6	4	2	2	2	21
Kansas	10	----	4	3	3	2	2	14
Kentucky	----	----	----	----	----	----	----	NS
Louisiana	10	4	2	1	----	----	----	7
Maine	5	1	1	----	----	----	----	2
Massachusetts	----	----	----	----	----	----	----	NS
Michigan	14	8	9	7	9	6	8	47
Minnesota	10	4	9	----	7	1	1	22
Nebraska	10	2	1	----	1	----	1	5
New Hampshire	----	----	----	----	----	----	----	NS
New Jersey	5	2	2	2	2	2	2	12
New York	20	7	7	7	7	7	7	42
North Dakota	10	6	6	6	6	5	6	34
Oklahoma	3	6	6	7	6	6	7	38
Oregon	15	4	3	10	2	2	2	23
Pennsylvania	10	7	7	9	8	6	7	44
Tennessee	8	6	6	6	6	6	6	36
Texas	10	4	13	9	10	9	5	50
Utah	10	28	55	25	1	1	----	110
Vermont	80	1	3	4	3	2	5	18
Washington	10	5	3	3	7	----	----	18
Wisconsin	10	7	13	10	12	12	11	65
State total	----	155	210	149	117	86	83	800
PMN	10	111	115	114	114	116	105	675
Total	----	266	325	263	231	202	188	1,475

NA, no analysis.
NS, no sample collected.

(*14*). Exceptions are Arizona and New Mexico where cattle are on dry-lot feeding, and California where cattle are on pasture and stored roughage (*14*).

The initial appearance of iodine–131 in milk lagged behind the cloud passage (figure 1) by approximately 2 days. The highest measured concentrations of iodine–131 in milk were found in the PMN samples collected between May 22 and 25 in the Midwest (figure 7 and table 6). A PMN sample was not collected in Arkansas on May 21 but a maximum concentration was observed by the Arkansas State Health Department for a milk sample collected in Sebastian County. The PMN sample collected closest to this maximum was that for May 24 with an iodine–131 concentration 41 percent of the State maximum, emphasizing the advantage of complementary data from Federal and State milk surveillance programs. Where the PMN provides the basis for determining geographical areas affected, the State program may furnish the detail required to determine maximum concentrations.

The relationship between the occurrence of iodine–131 in milk and bovine thyroids is seen in the graph for Region IV (figure 6). The concentrations of iodine–131 in milk follow the trend of the bovine thyroid levels.

Combining the results of the PMN and 29 State networks, the percentages of samples with iodine–131 activities greater than 20 pCi/liter were calculated on a regional basis for semiweekly intervals. A level of 20 pCi/liter was chosen in order to allow the use of results from 29 States. The results for the States of Idaho and Vermont were excluded from the calculations because their minimum detectable levels

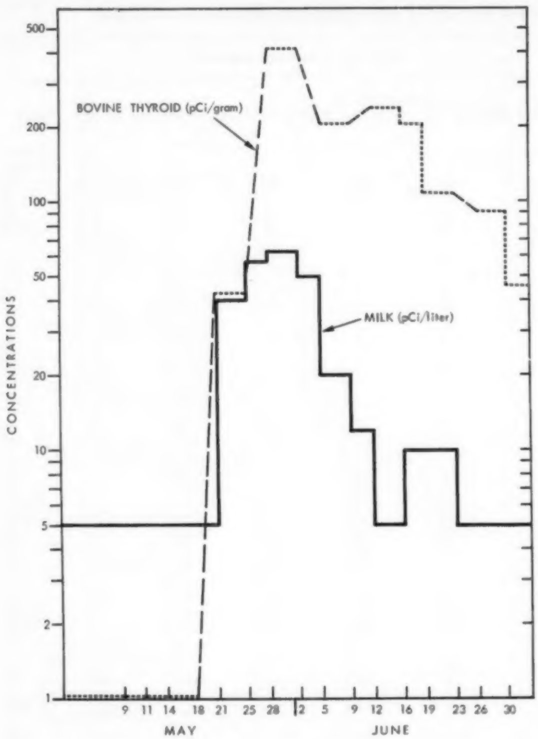

Figure 6. Average iodine-131 concentrations in bovine thyroids and milk for region IV (Georgia, Mississippi, and South Carolina) from May 9 through June 30, 1966

of iodine–131 in milk were greater than 20 pCi/liter. However, intrusion of iodine–131 into these States was minimal and exclusion of these data does not limit this evaluation. From the iodine–131 sample percentages greater than 20 pCi/liter (table 6), it is readily apparent that Regions III through VII exhibited the greatest intrusions. This is in agreement with the isograms of iodine–131 concentrations in PMN samples (figure 7) and total gross beta radioactivity deposition isograms (figure 2).

Determination of pasture half-time and intake

Because of the large number of milk samples collected through State and PHS programs, it was considered reasonable to estimate iodine–131 pasture half-times and deposition dates. According to the empirical equation developed by Lengemann (*15*), the ratio of the amount of radioiodine as a function of time, in a liter of milk corrected for radioactive decay to a constant daily radioiodine intake by the cow is given by the equation:

$$F(t) = (0.0091)(e^{0.021t})(1 - e^{-0.292t}) \qquad (1)$$

where

$F(t)$ = fraction of constant intake of radioiodine per liter of milk as a function of time, and

t = time after start of radioiodine intake (days).

Table 6. Percentages of milk samples collected with iodine-131 concentrations greater than 20 pCi/liter and maximum concentrations

Region [a] and State	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I (Percent)	0	0	0	0	29	13	14	17	0	0	0	0	0	0	0
Maximum (pCi/liter)	<10	<10	< 20	< 20	20	20	20	20	< 10	<10	11	<10	<10	<10	<10
Region II (Percent)	0	0	0	0	19	17	17	21	0	7	0	97	6	0	0
Maximum (pCi/liter)	<20	<20	< 20	< 20	< 20	20	40	30	< 20	24	<20	24	22	<20	<20
Region III (Percent)	0	0	17	20	100	100	100	67	17	17	33	0	0	20	0
Maximum (pCi/liter)	<10	<10	30	30	60	60	50	40	30	20	20	<10	<10	20	<10
Region IV (Percent)	0	0	11	20	83	82	100	100	42	36	7	18	18	------	0
Maximum (pCi/liter)	<10	<10	20	38	110	100	92	60	32	23	<20	20	20	10	<20
Region V (Percent)	0	0	0	40	44	94	63	50	27	45	32	40	0	13	0
Maximum (pCi/liter)	<10	<10	< 14	100	270	190	100	70	40	30	40	42	17	56	<14
Region VI (Percent)	0	0	7	11	52	72	67	70	65	78	67	67	18	13	0
Maximum (pCi/liter)	<10	<10	20	80	632	180	184	120	191	50	60	40	20	50	14
Region VII (Percent)	0	0	6	10	81	78	88	87	69	58	45	14	6	14	0
Maximum (pCi/liter)	<10	<10	159	922	810	480	254	118	93	77	68	20	20	20	10
Region VIII (Percent)	0	0	0	0	46	21	29	13	14	20	14	33	0	0	0
Maximum (pCi/liter)	<10	<10	15	14	269	84	136	167	20	30	20	20	<10	<10	<10
Region IX (Percent)	0	0	0	0	0	27	15	7	30	0	0	29	0	0	0
Maximum (pCi/liter)	<10	<10	< 10	< 10	< 10	30	20	40	20	<10	<10	20	<10	<10	<10
Alaska (Percent)	0	0	0	0	100	0	0	0	0	------	------	0	0	------	0
Hawaii (Percent)	0	0	100	0	0	------	0	0	0	0	0	0	0	0	0

[a] For identification of States within Region, see insert, figure 1.

This equation describes, for a constant radioiodine intake, the time relationship of radioiodine found per liter of milk if no radioactive decay occurs. Equation (1) was developed from data taken over a period of 14 days, at which time the ratio was still increasing. For periods greater than 14 days, equation (1) describes an increasing exponential function which doubles approximately every 33 days. If equilibrium conditions are actually reached in the cow at 14 days, then the iodine–131 concentration in milk would be overestimated by 43 percent at 30 days. However, since Lengemann has stated that observed radioiodine levels were still increasing after 2 weeks, the error can be assumed to be less than 43 percent.

Lengemann has suggested that the milk radioiodine concentration as a function of time be expressed as,

$$C(t) = I_0 \cdot R \cdot L \cdot F(t), \qquad (2)$$

where,

- I_0 = first day's intake of radioiodine by an average cow,
- R = factor representing radioactive decay between time of radioiodine intake and time of milking, and
- L = factor to account for loss of radioiodine from grass due to physical and chemical actions of the environment.

This report concerns itself with the iodine–131 concentration in milk at the time of milking. Therefore, it was not necessary to account for the loss of radioiodine due to physical decay during the period from milk production to consumption or the volume of milk consumed daily, which were also factors suggested by Lengemann.

When the appropriate factors are substituted into equation (2) the following equation describing iodine–131 concentration in milk as a function of time was obtained:

$$C(t) = I_o(e^{-0.086t})(e^{-\lambda_L t})[0.0091(e^{0.021t} - e^{-0.271t})] \qquad (3)$$

where,

- $C(t)$ = iodine-131 concentration in milk at time t (pCi/liter),
- t = time after start of radioiodine intake (days),
- I_o = cow's intake of radioiodine on first day (pCi), and
- λ_L = pasture weathering constant due to physical and chemical actions of the environment $= 0.693/t_{L\frac{1}{2}}$
- $t_{L\frac{1}{2}}$ = weathering pasture half-time (days).

Equation (3) reduces to the following:

$$C(t) = (0.0091)(I_o)[e^{-(0.065+\lambda_L)t} - e^{-(0.357+\lambda_L)t}] \qquad (4)$$

It should be pointed out that, although not stated in his paper, Lengemann assumed that the physical half-life of iodine–131 due to radioactive decay while in the cow is the same as the effective (physical and weathering) half-time of iodine–131 on pasture. Since this is not the actual case, the equation would tend to underestimate the actual concentration in milk. In the method described herein, involving pasture half-time templates, the estimated pasture half-times would tend to be higher than the actual pasture half-times.

Using equation (4), a series of transparent templates were developed for weathering pasture half-times (not including radioactive decay) of 2.94, 4.17, 5.21, 6.41, 7.79, 9.36, and 57.7 days. These iodine–131 weathering pasture half-times correspond to iodine–131 milk half-times of 2.3, 3.0, 3.5, 4.0, 4.5, 5.0, and 9.0 days, respectively, for the region of Lengemann's equation (3) where the curve describes an exponential decrease. Various observed State or PMN station results were then plotted on semilog paper and fitted by hand to the developed templates. The curve providing the best fit was selected and used to define the pasture half-time, the apparent date of deposition (start of intake), and the peak iodine–131 milk concentration. This method was used only for those sampling locations which met the following criteria:

1. At least one sample from the sampling site had a milk concentration of iodine–131 of 50 pCi/liter or greater.
2. Samples were collected at least once a week at the sampling site.
3. The second milk sample from a sampling site was collected within 3 days of the collection date of the first milk sample with detectable iodine–131; or, the first milk sample had a lower io-

dine–131 concentration than the second sample.

4. Collection from a sampling site was continued until iodine–131 concentrations in milk were below detectable levels.

Data from five States (Arkansas, Indiana, Oklahoma, Texas, Utah) and 18 PMN stations met the criteria. Although the samples reported on by the Utah State Health Department met the criteria, they were determined for samples collected from tank-trucks. When the data were plotted they could not be fitted to any of the developed templates. This was assumed to have resulted from large variations in iodine–131 concentrations in milk from the various farms on a tank-truck route.

It should be pointed out that the deposition date, defined by this method does not allow for the time delay between milking and collection. The collection date is used as though it were the milking date. Hence, the actual date of deposition most likely occurred earlier than the date derived by this method. Also, if the dairy herds in a given milkshed were not on pasture at the time of actual deposition but were put on pasture at a later date, the deposition date determined by the described method would lag behind the actual deposition date.

In those cases where the daily levels of iodine–131 in milk increased relative to the theoretical curves representing a single deposition event (*i.e.*, the cow's daily iodine–131 intake increased) a graphical subtraction was performed and the values replotted to give a second curve and apparent iodine–131 deposition date. This is an apparent deposition since other factors than an actual deposition could cause the same effect on iodine–131 concentrations in milk. Cows not initially on pasture could have been placed on pasture later, or cows on pasture could have been transferred to a new pasture where contamination was greater.

Comparison between iodine–131 deposition dates derived by this method and gross beta radioactivity deposition observed by the RSN (table 7) shows in a few cases a time lag of 1 to 3 days behind the RSN data, which would be expected. However, in most cases correlation was not good.

Data from these State and PMN locations (excluding those in Utah) were fitted with templates. For the locations studied, all but two yielded pasture half-times from four to nine days as shown in table 7. The two exceptions fitted the template whose weathering pasture half-time was 58 days. In order to adequately define the curve for the shorter weathering pasture half-times, optimum sample collection should be every 3 days. For the longer weathering pasture half-time, optimum sampling would be every 5 days. This insures that at least one sample is collected while the iodine–131 concentration is increasing. The above weathering pasture half-times (4 to 9 days) yield iodine–131 half-times in milk of 3 to 5 days at the point in time where the second term in the equation becomes insignificant and the equation defines an exponential decrease.

Accumulated iodine–131 intake

On the basis of the fitted curves, it is possible to estimate the total iodine–131 intake received by a member of the general population as a result of the third Chinese atmospheric nuclear test. Assuming a daily purchase and consumption of 1 liter of milk, the accumulated iodine–131 intake can be calculated by integrating equation (4). The iodine–131 concentration of the first day was obtained from the fitted curves.

Integrating equation (4) yields the total iodine–131 intake:

$$E=(0.0091)\ (I_o)\ [(0.065+\lambda_L)^{-1}-(0.357+\lambda_L)^{-1}] \quad (5)$$

where,

E = cumulative iodine-131 intake (pCi).

The calculated cumulative iodine–131 intake from drinking milk was 9,300 pCi in Sebastian County, Ark. This represents 1.7 percent of the Protective Action Guide for a suitable sample of a population group. The Protective Action Guide is defined by the Federal Radiation Council as the projected absorbed dose to individuals in the general population which warrants protective action following a contaminating event (*16*). The Protective Action Guide for a suitable sample of a population group is

Table 7. Iodine-131 weathering pasture half-times, deposition dates, and cumulative intakes from milk following the third Chinese nuclear test of May 9, 1966

Sampling location		Sampling code [a]	Template weathering pasture half-time (days)	Half-time in milk [b] (days)	Deposition date as determined from template fit	Observed deposition dates by RSN [c]	Milk concentration first day after intake [d] (pCi/liter)	Cumulative iodine-131 intake [e] (pCi)
Ala:	Montgomery	P	9	5.0	May 19, 29	May 19–22, 27–28, June 10	27, 12	870
Ark:	Little Rock	P	4	3.0	May 17, 31	[f]	440, 40	5,800
	Green County	S	4	3.0	May 18, 20		120, 380	6,000
	Lonoke County	S	4	3.0	May 16, 31		370, 42	5,000
	Miller County	S	4	3.0	May 19, 26		52, 68	1,500
	Quachita County	S	4	3.0	May 17, 23, 30		65, 40, 50	1,900
	Sebastian County	S	4	3.0	May 16, 20		550, 220	9,300
	Washington County	S	4	3.0	May 17, June 2		500, 40	6,500
Ga:	Atlanta	P	9	5.0	May 18, 28		24, 20	980
Ind:	Indianapolis	P	5	3.5	May 19, 23	May 18, 21, June 7	82, 68	2,200
	Fort Wayne	S	9	5.0	May 19		61	1,400
	Indianapolis	S	9	5.0	May 19	May 18, 21, June 7	94	2,100
	Rochester	S	8	4.5	May 19		160	3,100
Iowa:	Des Moines	P	9	5.0	May 22, June 1, 9		30, 9, 10	1,100
Kans:	Wichita	P	9	5.0	May 19, 31		62, 23	1,900
Minn:	Minneapolis	P	4	3.0	May 23, 29 June 7	May 15–17, 23, 25, June 2–3, 6	23, 31, 13	810
Miss:	Jackson	P	58	9.0	May 23	May 18–20, 22, 24	21	920
Mo:	Kansas City	P	9	5.0	May 19, June 7		82, 17	2,200
	St. Louis	P	9	5.0	May 19, 31		150, 19	3,800
Neb:	Omaha	P	9	5.0	May 26, June 8	[g] May 17, 20, 23, 30, June 3, 5, 7	51, 22	1,600
N.C.	Charlotte	P	58	9.0	May 18	[h] May 15, 22, 24	30	1,300
Ohio:	Cincinnati	P	8	4.5	May 20		39	760
Okla:	Oklahoma City	P	9	5.0	May 20, 27	May 21	77, 24	2,200
	Enid	S	9	5.0	May 23		56	1,200
	Lawton	S	9	5.0	May 22		60	1,300
S.C:	Charleston	P	9	5.0	May 23		54	1,200
Tenn:	Memphis	P	9	5.0	May 21		62	1,400
Tex:	Austin	P	9	5.0	May 23	May 25, 29	28	620
	Dallas	P	9	5.0	May 22		52	1,200
	Lubbock County	S	9	5.0	May 24		50	1,100

[a] P, PMN sampling location. S, State sampling location.
[b] For the time period where Lengemann's equation describes an exponential decrease.
[c] Gross beta radioactivity concentration of 200 pCi/liter or more per daily collection (time period—May 1 to June 10).
[d] Determined through template fit for each apparent deposition event.
[e] Assuming a 1 liter/day consumption rate.
[f] No RSN station at sampling location.
[g] RSN station—Lincoln, Nebr.
[h] RSN station—Gastonia, N.C.

one-third the Protective Action Guide for the individual.

Summary and discussion

On the basis of available information it is assumed that the intrusion of fresh fission products into the environment was the result of a single contamination event, the third Chinese atmospheric nuclear test. This data includes air, precipitation, bovine thyroid, and milk results obtained from May 9 through June 30, 1966, by both State and Public Health Service environmental surveillance programs.

During this period of time, increased levels of radioactive contamination were noted throughout the United States with peak activities occurring in the southern Midwest and southwestern Southeast. Radioactivity observed in mid-May increased steadily until late May when peak concentrations occurred in air, precipitation, bovine thyroids, and milk. Subsequently, environmental contamination decreased reaching essentially pre-intrusion values by the end of June.

A comparison between the various environmental media sampled can be made by considering results obtained in Region VII (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas). The appearance of fresh fission products in air was observed between May 15 and 18 as shown in figure 8. Later, the percentage of samples containing fresh fission products increased reaching a maximum between May 22 and 25. Although the greatest percentage of air samples was affected at that time, the peak air concentration in this region occurred on May 21. Subsequent to May 25, air radioactivity concentrations were observed to decrease except for a slight intrusion between June 5 and 7 which is presumed to reflect the second passage of the debris cloud.

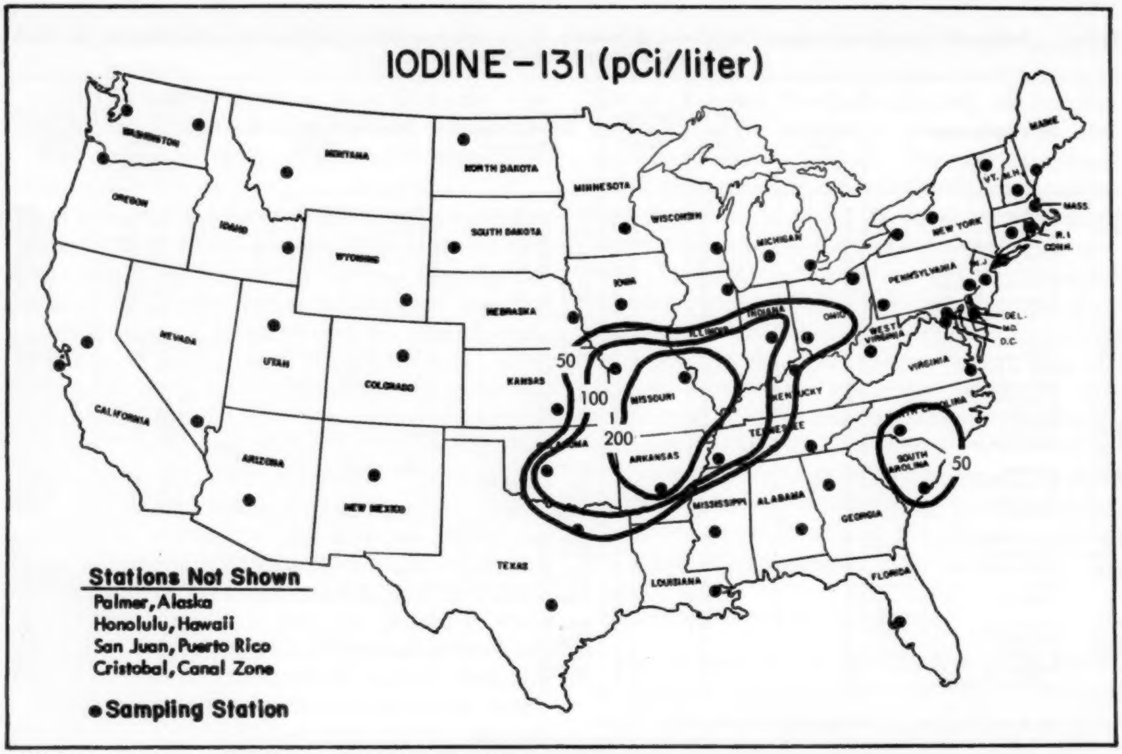

Figure 7. Iodine-131 concentrations in pasteurized milk, May 22 to 25, 1966

The percentage of precipitation samples with gross beta radioactivity concentrations greater than the minimum detectable level (200 pCi/liter) was seen to increase similarly with the percentage of air samples showing fresh fission products (figure 8). However, the precipitation sample percentages remained elevated for a greater length of time, not decreasing until mid-June.

Although the number of thyroid samples collected on any given day was small, the grouped results in terms of percentage of samples with activities greater than 10 pCi/g show a general trend of the influx of iodine-131 into the environment. It is difficult to relate thyroid iodine-131 levels to the levels observed in other environmental media; however, the influx of iodine-131 was readily observed by the Bovine Thyroid Network.

Initially, the percentage of milk samples with iodine-131 concentrations greater than 20 pCi/liter is seen to parallel the percentage of bovine thyroid results greater than 10 pCi/g; however, the milk percentages were observed to exhibit a decline sooner than the thyroid percentages. Peak iodine-131 concentrations in milk were observed to lag behind peak air gross beta radioactivities by approximately 7 days.

Equations developed by Lengemann were used to determine pasture iodine-131 weathering half-times of 4 to 9 days (two were 58 days) (*15*). Estimated iodine-131 deposition dates in a few cases lagged behind RSN observed gross beta radioactivity depositions by 1 to 3 days and reflected the time delays in the cow, time between milking, and sample collection. However, in most cases correlation was not good.

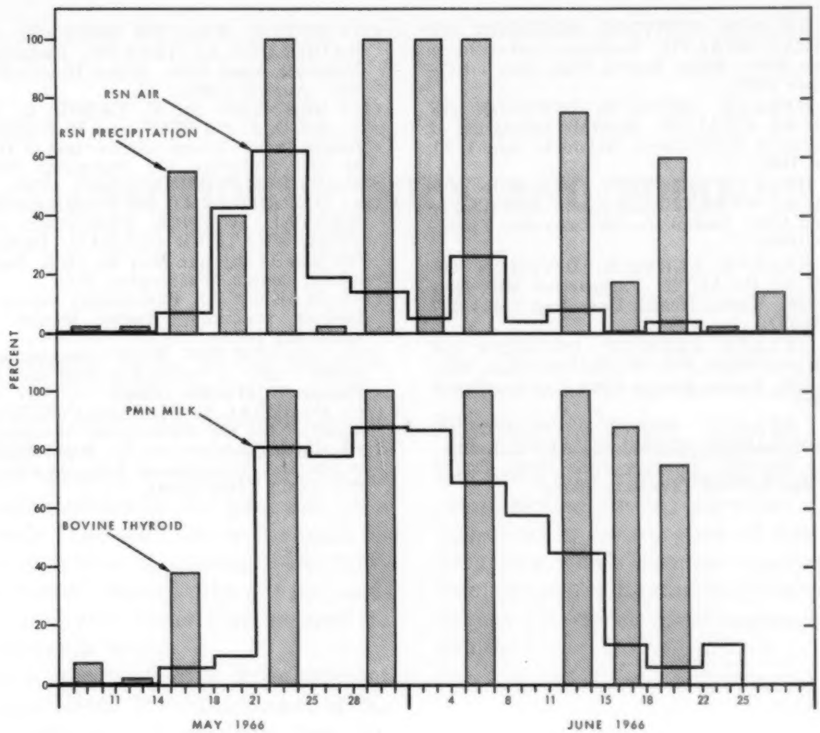

Figure 8. Percentage of air precipitation, bovine thyroids, and milk samples containing fresh fission products, region VII

Maximum iodine–131 concentrations in milk were observed in the central section of the Midwest and southwestern section of the Southeast with the peak iodine–131 concentration (920 pCi/liter) found for a sample collected in Arkansas on May 21, 1966. Cumulative intake of iodine–131 from drinking 1 liter of milk from Sebastian County, Arkansas (the county where the highest iodine–131 milk concentrations were reported) was calculated to correspond to 1.7 percent of the Protective Action Guide as defined by the Federal Radiation Council (*16*).

Acknowledgment

The authors wish to express their appreciation for the assistance received from the State personnel represented by the programs mentioned herein, without whose assistance this report would not have been possible.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Reported nuclear detonations, May 1966. Radiol Health Data Rep 7:376 (June 1966).
(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Reported nuclear detonations, October 1964. Radiol Health Data 5:577 (November 1964).
(*3*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Reported nuclear detonations, May 1965. Radiol Health Data 6:332 (June 1965).
(*4*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Monthly tabulations of findings. Radiation Surveillance Network, May 1–13, 1966 (July 8, 1966).

(*5*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radiation Surveillance Network, May 1966. Radio Health Data Rep 7:517–520 (September 1966).

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Monthly tabulation of findings. Radiation Surveillance Network, June 1–30, 1966 (August 1966).

(*7*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radiation Surveillance Network, June 1966. Radiol Health Data Rep 7:590–592 (October 1966).

(*8*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Pasteurized Milk Network, May 1966. Radiol Health Data Rep 7:494–497 (September 1966).

(*9*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Pasteurized Milk Network, June 1966. Radiol Health Data Rep 7:562–566 (October 1966).

(*10*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Iodine-131 in bovine thyroids, January–June 1966. Radiol Health Data Rep 8:51–55 (January 1967).

(*11*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radiation Surveillance Network, April 1966. Radiol Health Data Rep 7:466–469 (August 1966).

(*12*) BRANSON, B., E. TABOR, G. HOLZWORTH, S. GOLD, J. HARDIN, and B. KAHN. Detection of fallout from Chinese nuclear test of October 16, 1964, by the National Air Sampling Network. Radiol Health Data 6:188–192 (April 1965).

(*13*) DEPARTMENT OF COMMERCE, ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION, WEATHER BUREAU. Daily weather maps for May 15 through May 28, 1966. National Meteorological Center, Washington, D.C.

(*14*) OLSEN, C. D. Preliminary survey of dairy cattle feeding practices. Radiol Health Data 5:37–39 (January 1964).

(*15*) LENGEMANN, F. W. Predicting the total projected intake of radioiodine from milk by man. Health Physics 12:825–830 (1966).

(*16*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, because specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake.

Fresh milk is consumed by a large segment of the U.S. population. It contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet and is the major source of dietary intake of short-lived radionuclides. For these reasons it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific dietary information, one may assume that the total daily dietary intake of selected radionuclides is equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analysis of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N.Y. (1965).

National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs presented below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	January–June 1966	March 1967

1. Pasteurized Milk Network February 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	Less than 100	10	100 or greater	10
Barium-140	Less than 100	10	100 or greater	10
Cesium-137	Less than 100	10	100 or greater	10
Strontium-89	Less than 50	5	50 or greater	10
Strontium-90	Less than 20	2	20 or greater	10

[a] Two standard deviations.

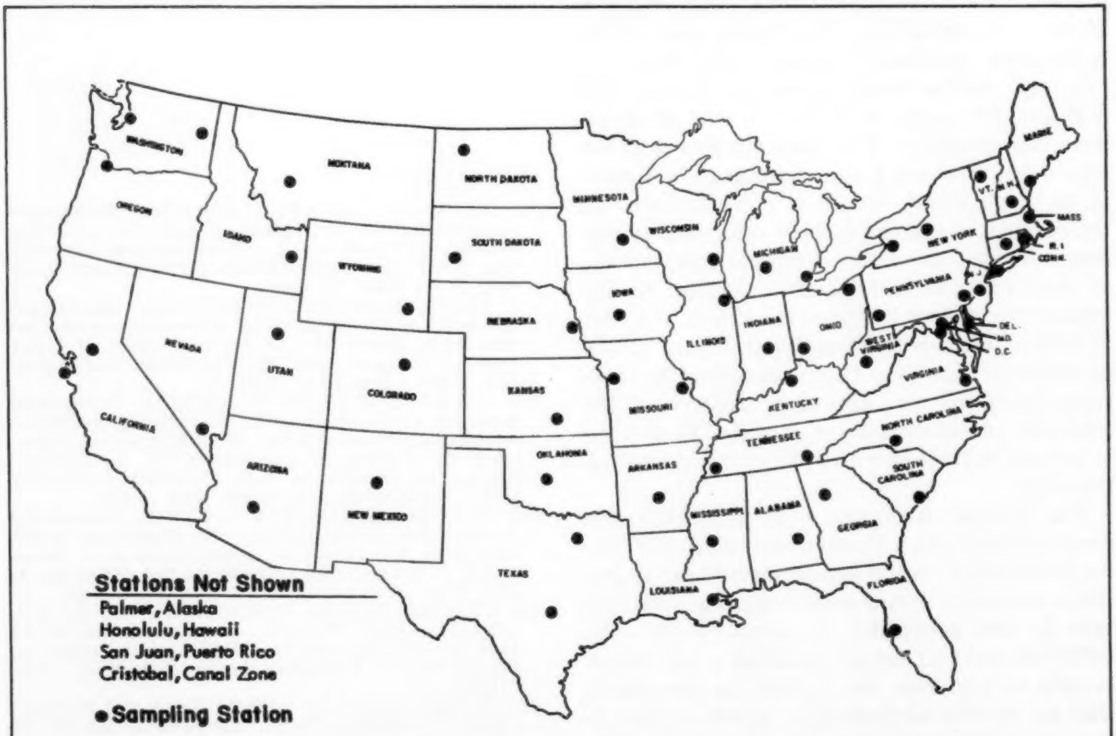

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentration of radionuclides in pasteurized milk for the fourth quarter 1966 and February 1967

Sampling location		Concentration (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter 1966	Feb [a] 1967	Fourth quarter 1966	Feb 1967	Fourth quarter 1966	Feb 1967	Fourth quarter 1966	Feb 1967	Fourth quarter 1966	Feb 1967
Ala:	Montgomery	< 5	<5	10	11	0	0	15	15	0	0
Alaska:	Palmer	< 5	<5	14	8	0	0	25	15	0	0
Ariz:	Phoenix	< 5	<5	3	2	0	0	5	< 5	0	0
Ark:	Little Rock	5	<5	24	21	0	0	20	20	0	0
Calif:	Sacramento	< 5	<5	3	4	0	0	5	< 5	0	0
	San Francisco	< 5	<5	3	3	0	0	10	< 5	0	0
C. Z:	Cristobal	< 5	<5	5	5	0	0	25	20	0	0
Colo:	Denver	< 5	<5	8	6	0	0	10	< 5	0	0
Conn:	Hartford	< 5	----------	10	10	0	0	20	20	0	0
Del:	Wilmington	< 5	----------	12	11	0	0	20	20	0	0
D. C:	Washington	< 5	<5	12	9	0	0	15	20	0	0
Fla:	Tampa	10	<5	10	9	0	0	95	80	0	0
Ga:	Atlanta	5	<5	16	16	0	0	25	25	0	0
Hawaii:	Honolulu	< 5	<5	4	4	0	0	15	10	0	10
Idaho:	Idaho Falls	< 5	<5	9	7	0	0	15	< 5	0	0
Ill:	Chicago	< 5	<5	8	9	0	0	15	20	0	0
Ind:	Indianapolis	< 5	----------	10	11	0	0	15	20	0	0
Iowa:	Des Moines	< 5	<5	9	9	0	0	15	< 5	0	0
Kans:	Wichita	< 5	<5	14	8	0	0	10	< 5	0	0
Ky:	Louisville	10	<5	13	13	0	0	10	15	0	0
La:	New Orleans	< 5	<5	27	25	0	0	35	30	0	0
Maine:	Portland	< 5	----------	14	13	0	0	45	45	0	0
Md:	Baltimore	< 5	<5	11	11	0	0	15	20	0	0
Mass:	Boston	< 5	<5	13	13	0	0	35	35	0	0
Mich:	Detroit	< 5	----------	10	10	0	0	15	20	0	0
	Grand Rapids	< 5	----------	12	10	0	0	20	25	0	0
Minn:	Minneapolis	< 5	<5	21	15	0	0	15	10	0	0
Miss:	Jackson	15	<5	17	19	0	0	15	20	0	0
Mo:	Kansas City	< 5	<5	11	10	0	0	10	< 5	0	0
	St. Louis	< 5	<5	12	11	0	0	15	5	0	0
Mont:	Helena	< 5	<5	12	7	0	0	20	5	0	0
Nebr:	Omaha	< 5	<5	10	10	0	0	10	< 5	0	0
Nev:	Las Vegas	< 5	<5	3	2	0	0	10	< 5	0	0
N. H:	Manchester	< 5	----------	15	17	0	0	45	45	0	0
N. J:	Trenton	< 5	----------	10	10	0	0	20	25	0	0
N. Mex:	Albuquerque	< 5	<5	4	5	0	0	5	< 5	0	0
N. Y:	Buffalo	< 5	----------	9	9	0	0	20	20	0	0
	New York City	< 5	----------	12	10	0	0	25	25	0	0
	Syracuse	< 5	----------	9	10	0	0	20	20	0	0
N. C:	Charlotte	< 5	<5	20	18	0	0	20	20	0	0
N. Dak:	Minot	< 5	<5	24	17	0	0	20	15	0	0
Ohio:	Cincinnati	< 5	----------	10	11	0	0	15	20	0	0
	Cleveland	< 5	----------	10	11	0	0	20	20	0	0
Okla:	Oklahoma City	< 5	<5	9	10	0	0	10	10	0	0
Ore:	Portland	< 5	<5	10	7	0	0	20	10	0	0
Penn:	Philadelphia	< 5	----------	11	11	0	0	20	20	0	0
	Pittsburgh	< 5	----------	14	15	0	0	20	25	0	0
P. R:	San Juan	5	<5	6	6	0	0	15	15	0	0
R. I:	Providence	< 5	----------	12	11	0	0	25	30	0	0
S. C:	Charleston	< 5	<5	20	18	0	0	30	30	0	0
S. Dak:	Rapid City	< 5	<5	16	12	0	0	15	10	0	0
Tenn:	Chattanooga	< 5	<5	18	16	0	0	20	20	0	0
	Memphis	< 5	<5	14	13	0	0	10	10	0	0
Tex:	Austin	< 5	<5	4	4	0	0	5	10	0	0
	Dallas	< 5	<5	10	9	0	0	10	15	0	0
Utah:	Salt Lake City	< 5	<5	12	8	0	0	15	5	0	0
Vt:	Burlington	< 5	----------	11	11	0	10	25	30	0	0
Va:	Norfolk	10	<5	14	12	0	0	15	15	0	0
Wash:	Seattle	< 5	<5	16	11	0	0	35	25	0	0
	Spokane	< 5	<5	14	11	0	0	25	20	0	0
W. Va:	Charleston	5	<5	15	12	0	0	10	10	0	0
Wisc:	Milwaukee	< 5	----------	9	8	0	0	15	20	0	0
Wyo:	Laramie	< 5	<5	8	5	0	0	10	5	0	0
Network average		< 5	<5	11.7	10.5	0	0	20	15	0	0

[a] Dashes indicate no strontium-89 determinations were made on samples from station during month.

sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (*1*).

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The results for February 1967 and the fourth quarter of 1966 are presented in table 2. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable values; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 3 and 4 for February 1966 and September 1966 through February 1967. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution of monthly average strontium-90 concentration in milk at PMN stations, February, September-December 1966 and January-February 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966					1967	
	Feb	Sept	Oct	Nov	Dec	Jan	Feb
Under 10	9	21	18	19	23	24	21
10–19	46	37	39	40	35	36	38
20–29	7	5	6	4	5	3	4
30–39	1	0	0	0	0	0	0

Table 4. Frequency distribution of monthly average cesium-137 in milk at PMN stations, February, September-December 1966 and January-February 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966					1967	
	Feb	Sept	Oct	Nov	Dec	Jan	Feb
Under 50	56	61	62	61	62	62	62
50–99	6	1	0	2	1	1	1
100–149	1	1	1	0	0	0	0

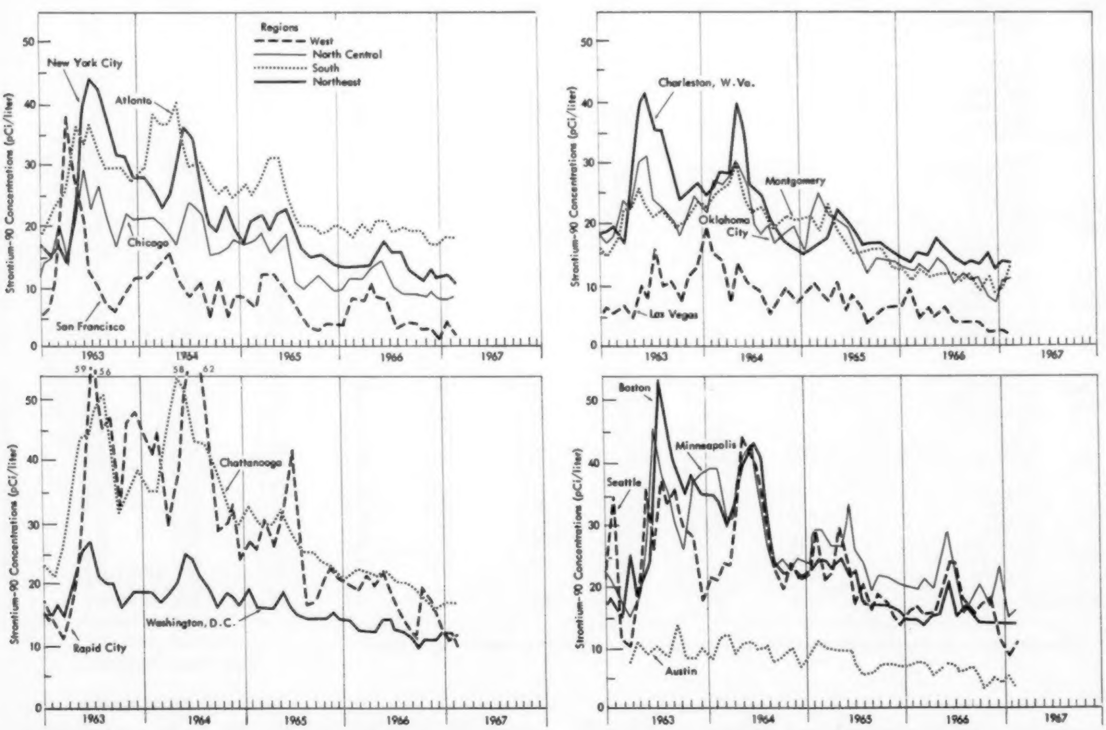

Figure 2. Strontium–90 concentrations in pasteurized milk 1961–February 1967

2. Canadian Milk Network February 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*2*).

The February 1967 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 and strontium–89 were below minimum detectable levels.

[1] Prepared from March 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 5. Stable elements and radionuclides in Canadian whole milk, February 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.14	1.3	11.7	34
Edmonton	1.12	1.5	12.2	40
Ft. William	1.13	1.4	17.1	36
Fredericton	1.11	1.4	16.7	44
Halifax	1.17	1.5	19.8	47
Montreal	1.08	1.4	12.9	31
Ottawa	1.16	1.4	10.6	29
Quebec	1.10	1.5	15.2	53
Regina	1.10	1.4	10.6	29
St. John's	1.08	1.5	19.4	64
Saskatoon	1.14	1.5	13.9	27
Sault Ste. Marie	1.10	1.5	13.9	51
Toronto	1.14	1.5	6.7	23
Vancouver	1.20	1.3	17.7	76
Windsor	1.17	1.5	6.6	16
Winnipeg	1.09	1.5	9.2	32
Average	1.13	1.5	13.4	40

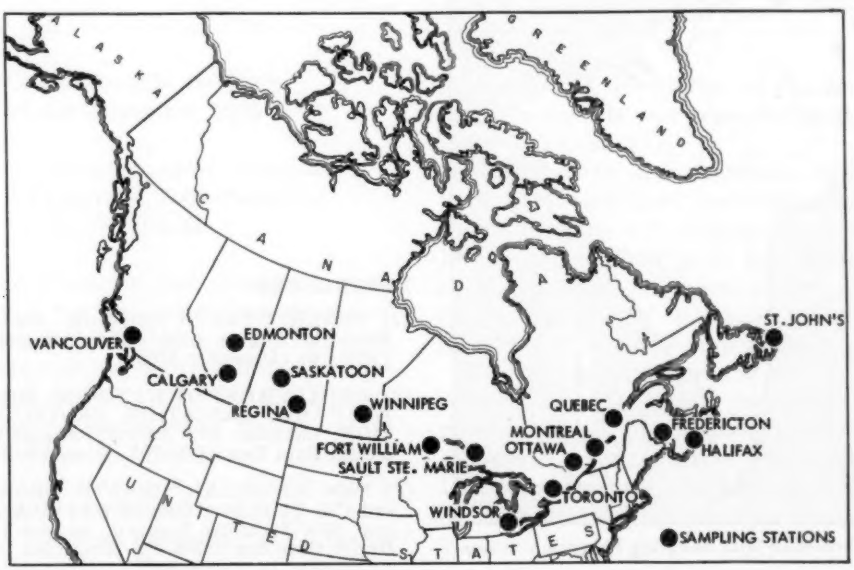

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program February 1967

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

Figure 4. Pan American Milk Sampling Program stations

Table 6 presents stable potassium, strontium-90 and cesium-137 monthly average concentrations for February 1967.

Table 6. Stable element and radionuclide concentrations in PAHO milk, February 1967

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:				
Santiago	4	1.53	<1	< 5
Colombia:				
Bogota	1	1.39	2	5
Ecuador:				
Guayaquil	NS			
Jamaica:				
Kingston	NS			
Mandeville	NS			
Montego Bay	NS			
Venezuela:				
Caracas:				
October 1966	1	1.39	3	< 5
November 1966	1	1.39	3	5
Canal Zone:				
Cristobal [b]	4	----------	6	20
Puerto Rico:				
San Juan [b]	4	----------	6	15

[a] Strontium-89 concentrations were less than 5 pCi/liter and iodine-131 and barium-140 concentrations were less than 10 pCi/liter for all samples.
[b] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico from the Pasteurized Milk Network are presented.
NS, no sample collected.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7:698–701 (December 1966).

(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period covered	Last presented
Connecticut	October–December 1966	May 1967
Colorado	May 1965–June 1966	October 1966
Florida	April–June 1966	October 1966
Indiana	October–December 1966	May 1967
Michigan	October–December 1966	May 1967
Minnesota	October–December 1966	May 1967
New York	October–December 1966	May 1967
Oklahoma	October–December 1966	April 1967
Pennsylvania	October–December 1966	May 1967
Tennessee	July 1965–June 1966	April 1967
Texas	October–December 1966	April 1967

1. California Milk Network October–December 1966

Division of Environmental Sanitation
State of California, Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for October to December 1966.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1966	December 1966
July–September 1966	March 1967

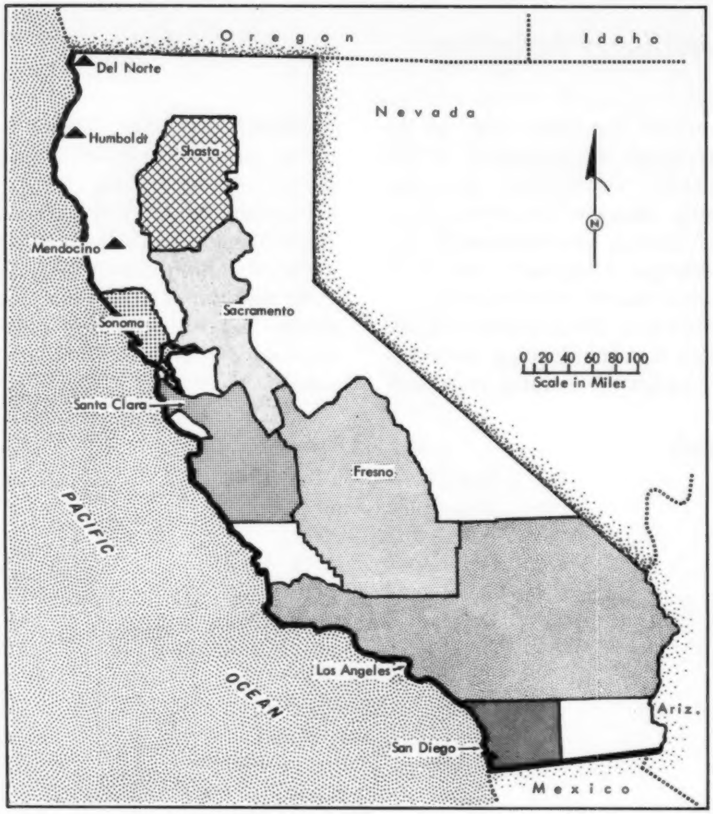

Figure 1. California milksheds

Table 1. Stable elements and radionuclides in California milk, October-December 1966

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-89 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Del Norte	1.32	1.30	NA	1,140	1,040	NA	[a] 4	72	NA	19	27	NA	21	27	NA
Fresno	1.19	1.16	1.22	1,170	1,230	1,120	ND	3	1	3	3	2	13	[a] 31	11
Humboldt	1.30	1.17	1.27	1,180	1,090	1,120	ND	8	10	6	5	8	11	[a] 6	16
Los Angeles	1.11	1.14	1.13	1,280	1,240	1,210	ND	ND	[a] 1	3	2	2	9	[a] 4	[a] 9
Mendocino	1.17	1.27	1.20	1,290	1,270	1,160	ND	[a] 3	[a] 1	5	3	3	4	14	7
Sacramento	1.18	1.23	1.25	1,210	1,190	1,220	ND	[a] 1	[a] 2	3	3	2	22	[a] 4	[a] 8
San Diego	1.15	1.14	1.13	1,350	1,250	1,240	ND	[a] 1	[a] 1	2	2	1	[a] 5	ND	[a] 5
Santa Clara	1.11	1.16	1.17	1,200	1,290	1,140	ND	[a] 1	ND	2	2	2	[a] 5	[a] 2	[a] 8
Shasta	1.15	1.15	1.13	1,220	1,240	1,160	ND	ND	ND	5	5	4	[a] 6	9	11
Sonoma	1.21	1.22	1.20	1,320	1,280	1,260	ND	ND	[a] 1	3	4	3	ND	[a] 6	[a] 4
Average	1.19	1.20	1.19	1,236	1,212	1,181	[b] ND	[b] 9	[b] 2	5	6	3	[b] 10	[b] 10	[b] 9

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
[b] Average is an estimate because 10 percent or more of the values averaged were not statistically significant.
NA, no analysis performed.
ND, non-detectable.

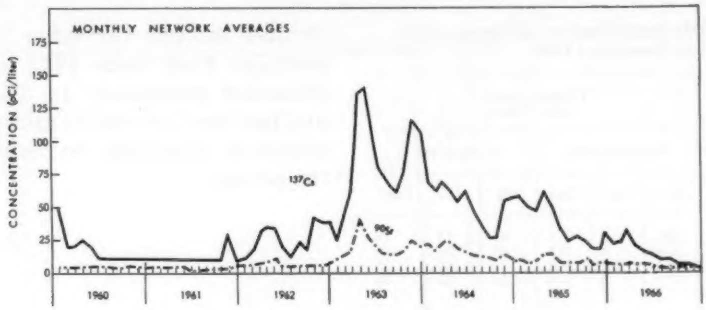

Figure 2. Radionuclide concentrations in California milk 1960–December 1966

2. Oregon Milk Network October–December 1966

Division of Sanitation and Engineering Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in pasteurized milk since March 1962 as part of its environmental radiation surveillance program. Currently, the Oregon milk network is comprised of seven climatically different production areas representing 90 percent of the milk distributed in Oregon (figure 3). The samples are obtained weekly in the Portland area by the City of Portland and monthly in the remaining statewide areas by the Oregon Department of Agriculture. When significant increases in radionuclide concentrations are observed, accelerated sampling is undertaken to evaluate the resulting trends.

Strontium–90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2 gives the strontium–90 and cesium–137 concentrations in pasteurized milk from the seven milk producing areas for the period

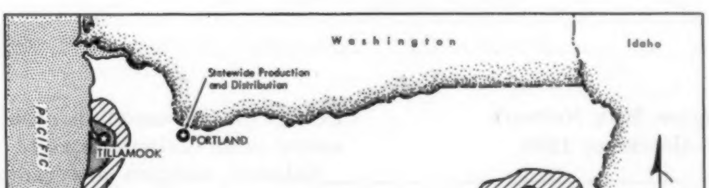

Figure 3. Oregon milk production and distribution areas

Table 2. Radionuclide concentrations in Oregon milk October-December 1966

Location	Sampling frequency[a]	Concentration (pCi/liter) Strontium-90 Oct	Strontium-90 Nov	Strontium-90 Dec	Cesium-137 Oct	Cesium-137 Nov	Cesium-137 Dec
Baker	M	NA	7	NA	40	15	15
Coos Bay	M	NA	8	NA	40	25	20
Eugene	M	NA	9	NA	25	20	15
Medford	M	NA	6	NA	<15	25	25
Nyssa[b]							
Portland composite	W	NA	11	NA	36	27	26
Portland local	W	NA	9	NA	35	23	26
Redmond	M	NA	7	NA	30	<15	25
Tillamook	M	NA	12	NA	40	85	35
Average	--------	------	9	------	33	29	23

[a] M, sampled monthly
W, sampled weekly
[b] Location discontinued in September 1966.
NA, no analysis.

October through December 1966. The network averages from June 1962 to the present are presented graphically in figure 4. Iodine–131 and barium–140 concentrations remained below minimum detectable levels of 15 pCi/liter for the period.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1966	December 1966
July–September 1966	March 1967

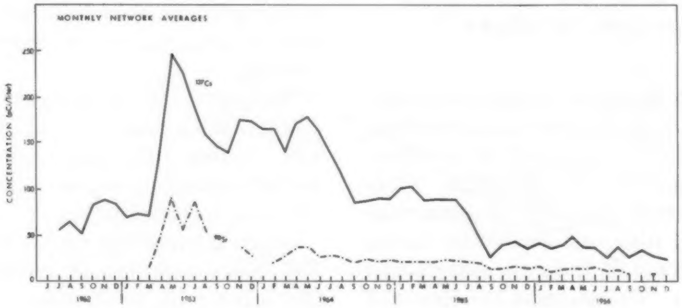

Figure 4. Radionuclide concentrations in Oregon milk network June 1962–December 1966

3. Washington Milk Network October–December 1966

Air Sanitation and Radiation Control Section State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented in an earlier report (*5*).

Selected samples are radiochemically analyzed for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for October through December 1966. Three samples collected in western Washington on November 9 showed iodine–131 levels of 13, 17, and 64 pCi/liter as a result of the October 27, 1966, Chinese mainland nuclear test. Samples collected both prior and subsequent to November 9 contained

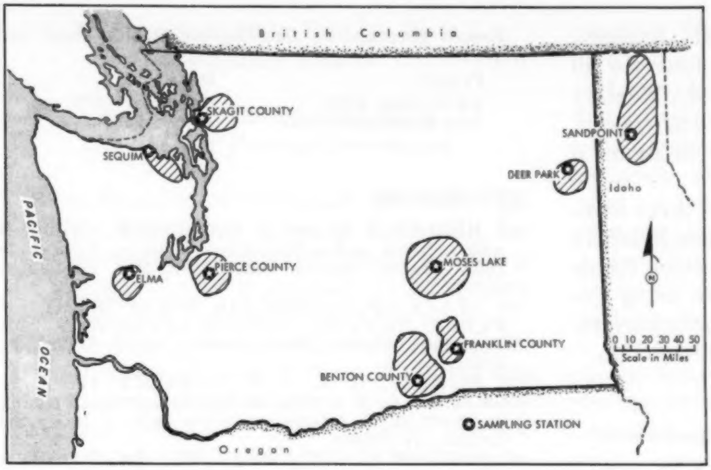

Figure 5. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington milk, October-December 1966

Sampling location	Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Benton County	1,190	NS	1,210	5	NS	5	16	NS	ND
Deer Park	1,280	[a] 1,325	1,140	8	[a] 7	10	22	[a] 22	28
Elma	1,240	[a] 1,205	1,140	14	11	7	47	[a] 38	21
Franklin County	NS	1,190	NS	NS	4	NS	NS	ND	NS
Moses Lake	[a] 1,285	1,300	1,190	[a] 6	5	5	[a] 15	ND	ND
Pierce County	1,340	[a] 1,310	1,150	8	8	9	32	[a] 32	19
Sandpoint	[a] 1,220	1,230	1,230	[a] 23	26	24	[a] 51	47	52
Sequim	1,280	1,150	1,190	6	7	7	19	21	18
Skagit County	1,190	[a] 1,350	1,180	12	11	10	22	[a] 28	21
Average	1,253	1,258	1,179	10	10	10	28	27	24

[a] Represents an average of two samples collected at these sampling locations during the month.
NS, no sample collected.
ND, non-detectable (less than 15 pCi/liter).

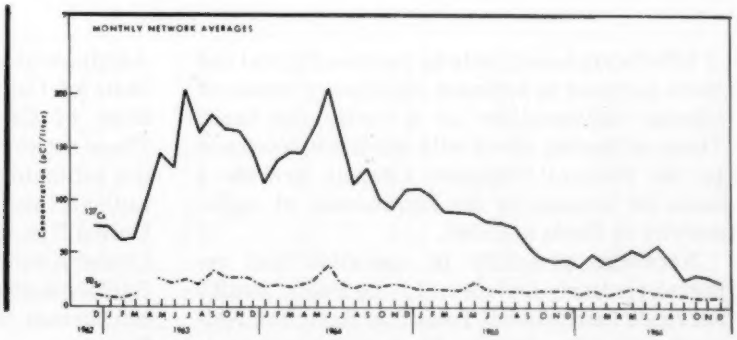

Figure 6. Radionuclide concentrations in Washington milk December 1962–December 1966

less than 10 pCi/liter of iodine–131. Barium–140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 6 to display general trends.

Zinc–65 was identified in one of three samples collected in the Benton County-Franklin County area during this reporting period (table 4). Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

Table 4. Washington milk samples containing zinc-65 October-December 1966

Sampling location	Collection date 1966	Zinc-65 (pCi/liter)
Benton County	October 10	< 25
Franklin County	November 10	480
Benton County	December 8	< 25

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1966	December 1966
July–September 1966	March 1967

REFERENCES

(*1*) HESLEP, J. M. and A. C. CORNISH. California milk network and milkshed comparisons, April–June 1963. Radiol Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960–June 1962. Radiol Health Data 4:90–92 (February 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium–90 determinations in milk. J Dairy Sci 43:151–154 (1960).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April–June 1965. Radiol Health Data 6:683–684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR SANITATION AND RADIATION CONTROL SECTION. Washington milk network, January–June 1965. Radiol Health Data 6:619–621 (November 1965).

Food and Diet Surveillance Activities

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States.

1. Strontium–90 in Tri-City Diets May–July 1966 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these 3 cities every 3 months on a staggered basis (*i.e.*, New York City, May 1966; San Francisco, June 1966; and Chicago, July 1966) and are analyzed for strontium–90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium–90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium–90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate their contribution to the total strontium–90 dietary intake. These values are added to contributions of the other 14 food categories to obtain quarterly estimates of annual strontium–90 intake at the 3 cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and the average calcium content

[1] Data from Fallout Program Quarterly Summary Report, HASL 181. Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, May-July 1966

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City, May 1966		Chicago, July 1966		San Francisco, June 1966	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Bakery products	37	37.0	16.4	607	12.9	477	7.5	278
Whole grain products	11	10.0	47.3	520	24.1	265	24.6	271
Fresh vegetables	43	15.0	12.9	555	16.3	701	5.8	249
Root vegetables	17	6.1	9.7	165	13.8	235	6.3	107
Milk	221	234.4	15.3	3,381	9.2	2,033	2.5	553
Flour	43	8.6	21.9	942	17.6	757	5.7	245
Macaroni	3	0.7	11.0	33	11.0	33	7.7	23
Rice	3	1.1	4.3	13	2.3	7	2.6	8
Dried beans	3	2.9	6.7	20	14.6	44	7.5	23
Fresh fruit	68	12.6	9.6	653	3.7	252	1.2	82
Potatoes	45	5.8	9.7	437	5.3	239	1.5	68
Canned fruit	26	1.3	2.1	55	2.3	60	1.3	34
Fruit juices	19	1.7	6.0	131	5.8	110	3.3	63
Canned vegetables	20	4.2	14.0	280	14.0	280	4.6	92
Meat, fish, poultry, shellfish, and eggs	99	42.0		[a] 410		[a] 289		[a] 110
Annual intake		383		8,202		5,782		2,206
Daily intake		1.05		22.5		15.8		6.0
pCi strontium-90/g Ca				21		15		6

[a] Estimated as 5 percent of total intake.

of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the May to June 1966 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1. A discussion of cesium–137 intakes as reflected in the Tri-City Diet Study has been presented previously (*4*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
May–July 1965	March 1966
August–October 1965	June 1966
November 1965–January 1966	September 1966
February–April 1966	December 1966

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1, 1955. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report, HASL–144:281–287. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964); summarized in Radiol Health Data 5:285–288 (June 1964).

(*3*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1964).

(*4*) U.S. ATOMIC ENERGY COMMISSION. Cesium–137 in Tri-City diets, 1965. Radiol Health Data Rep 8:154–157 (March 1967).

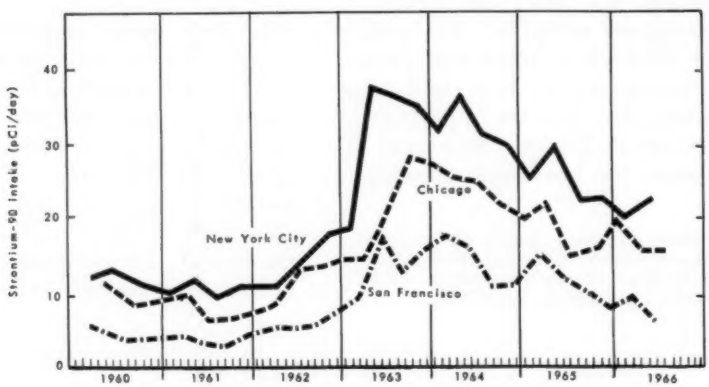

Figure 1. Daily intake of strontium–90 in Tri-City diet March 1960–July 1966

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter, and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence [1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the safe limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Program	Period reported	Last presented
Coast Guard Water Sampling	1965	November 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Drinking Water Analysis	1962	October 1965
Florida Water Sampling	1964	November 1966
Kentucky Water Sampling	May 1963–June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Minnesota Surface Water Sampling	January–June 1966	January 1967
New York Surface Water Sampling	June–December 1965	June 1966
North Carolina Water Sampling	1964	November 1965
Washington Surface Water Sampling	July 1964–June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961, reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, December 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already pro-

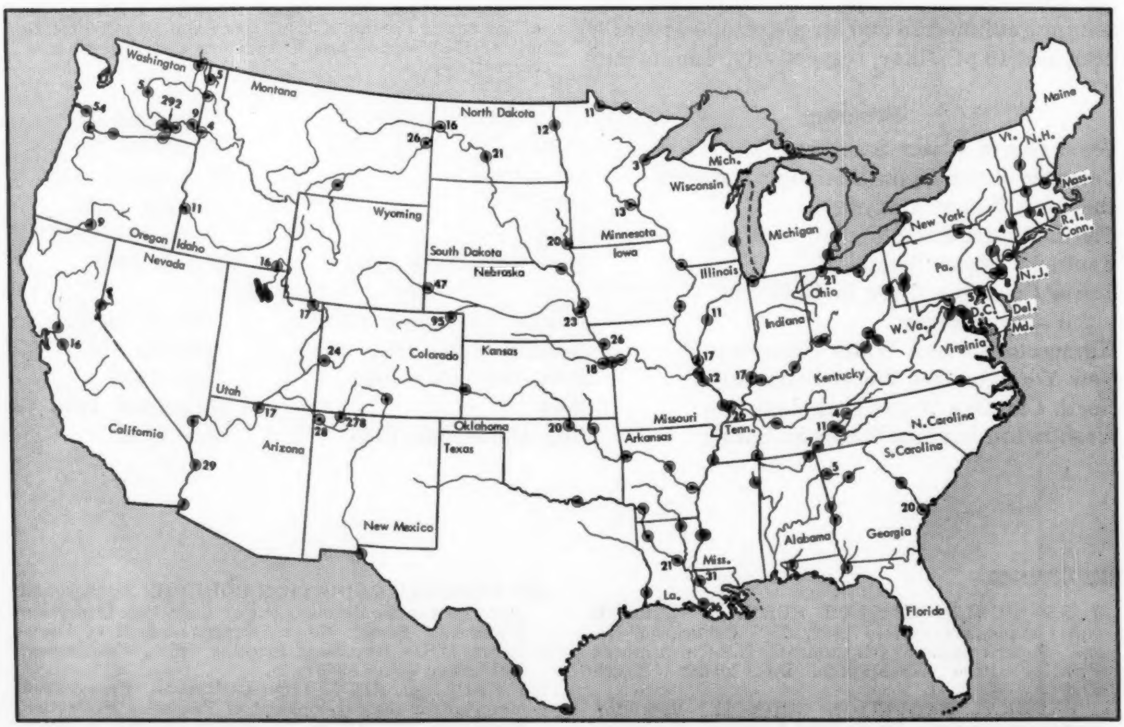

Figure 1. Sampling locations and associated total gross beta radioactivity (pCi/liter) for surface waters, December 1966

vided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both November and December 1966, the following stations showed alpha radioactivity in excess of 15 pCi/liter on either dissolved or suspended solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During December 1966, Loma, Colo., on the Colorado River showed a decline of alpha radioactivity to less than 15 pCi/liter on suspended solids.

Cedar Hill, N. Mex., on the Animas River, as a result of a single sample collected December 7, 1966, with a very high quantity of suspended solids, showed both alpha and beta radioactivities in excess of 15 pCi/liter and 150 pCi/liter, respectively, for the monthly average. Pasco, Wash., on the Columbia River showed beta radioactivity on dissolved solids in excess of 150 pCi/liter.

Table 1. Radioactivity in raw surface waters, December 1966

Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	269	9	278	73	1	74
Arkansas River:						
Ponca City, Okla	2	18	20	0	5	5
Atchafalaya River:						
Morgan City, La	27	9	36	10	1	11
Bear River:						
Preston, Idaho	0	16	16	0	2	2
Big Sioux River:						
Sioux Falls, S. Dak	1	19	20	0	3	3
Chena River:						
Fairbanks, Alaska	0	2	2	0	0	0
Clearwater River:						
Lewiston, Idaho	2	2	4	0	0	0
Clinch River:						
Clinton, Tenn	0	4	4	0	0	0
Kingston, Tenn [a]	1	10	11	0	< 1	< 1
Colorado River:						
Loma, Colo	10	14	24	3	8	11
Page, Ariz	0	17	17	0	4	4
Parker Dam, Calif-Ariz	2	27	29	0	10	10
Columbia River:						
Wenatchee, Wash	1	4	5	0	0	0
Pasco, Wash [a]	49	243	292	0	< 1	< 1
Clatskanie, Ore	13	42	54	0	0	0
Connecticut River:						
Enfield Dam, Conn	1	3	4	0	0	0
Coosa River:						
Rome, Ga	2	3	5	< 1	0	< 1
Delaware River:						
Philadelphia, Pa	3	5	8	1	0	1
Great Lakes:						
Duluth, Minn	0	3	3	0	0	0
Green River:						
Dutch John, Utah	0	17	17	0	3	3
Hudson River:						
Poughkeepsie, N.Y	1	3	4	0	0	0
Illinois River:						
Peoria, Ill	1	10	11	0	1	1
Grafton, Ill	6	11	17	1	0	1
Kansas River:						
DeSoto, Kans	1	17	18	0	3	3
Klamath River:						
Keno, Ore	2	7	9	0	0	0
Maumee River:						
Toledo, Ohio	8	13	21	3	1	4
Mississippi River:						
St. Paul, Minn	0	13	13	0	1	1
E. St. Louis, Ill	3	9	12	0	1	1
New Roads, La	9	22	31	2	1	3
New Orleans, La	1	8	9	0	1	1
Missouri River:						
Williston, N. Dak	2	14	16	1	4	5
Bismarck, N. Dak	5	16	21	1	4	5
St. Joseph, Mo	3	23	26	0	3	3
North Platte River:						
Henry, Nebr	7	40	47	< 1	32	32
Ohio River:						
Cairo, Ill	16	10	26	4	0	4
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	4	5	0	< 1	< 1
Platte River:						
Plattsmouth, Nebr	6	17	23	2	9	11
Potomac River:						
Washington, D.C	0	4	4	0	0	0
Rainy River:						
Baudette, Minn	< 1	11	11	0	0	0
Red River, North:						
Grand Forks, N. Dak	1	11	12	0	1	1
Red River, South:						
Alexandria, La	2	19	21	0	0	0
San Joaquin River:						
Vernalis, Calif	7	9	16	1	2	3
San Juan River:						
Shiprock, N. Mex	14	14	28	5	6	11
Savannah River:						
Port Wentworth, Ga [a]	4	16	20	0	0	0
Snake River:						
Payette, Idaho	1	10	11	0	4	4
Wawawai, Wash	1	8	9	0	2	2
South Platte River:						
Julesburg, Colo	19	76	95	3	35	38
Susquehanna River:						
Conowingo, Md	1	4	5	0	0	0
Tennessee River:						
Chattanooga, Tenn	< 1	7	7	0	0	0
Wabash River:						
New Harmony, Ind	7	10	17	2	1	3
Yellowstone River:						
Sidney, Mont	1	25	26	0	4	4
Maximum	269	243	292	73	35	74
Minimum	0	2	2	0	0	0

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised, 1963 Edition). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Radiostrontium in Tap Water, March–November 1966[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137/strontium-90 ratios in New York City tap water for March through November 1966 are presented in table 1. These results appear graphically in figure 1.

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL-181. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Radiostrontium in New York City tap water March-November 1966

Date 1966	New York City	
	Strontium-90 [a] (pCi/liter)	Cesium-137/ strontium-90 ratio
March	1.54	0.13
April	.58	.14
May	1.19	.18
June	1.62	.17
July	.92	.24
August	.86	.21
September	.82	.12
October	.76	.09
November	.80	.14

[a] Approximately 100 liters per sample.

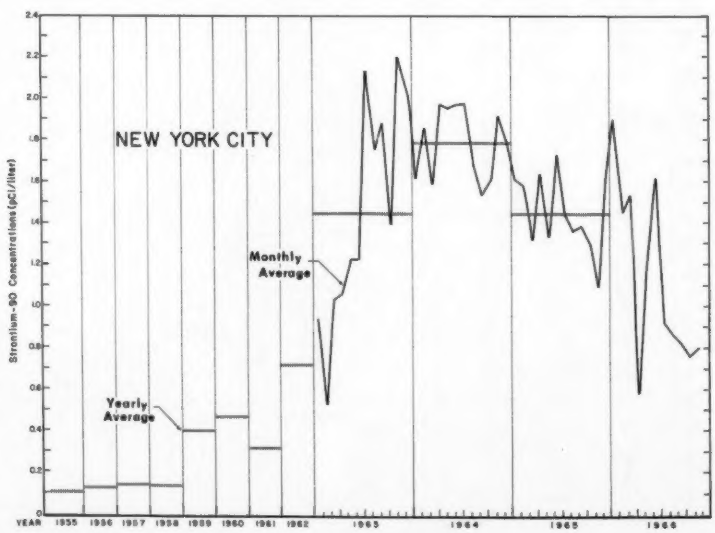

Figure 1. Strontium-90 concentrations in New York City tap water

A decreasing trend has been observed in the strontium–90 concentrations since the July 1963 peak. The maximum strontium–90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
May and July–November 1965	June 1966
November 1965–June 1966	December 1966

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E–38–01–16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, N.Y.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1-Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Radioactivity in California Waters,[1] January–June 1966

Bureau of Radiological Health, State of California Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This procedural change is predicted upon sampling water at the point of consumption.

Most of the supplies sampled have, as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500-ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450° C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Gamma-emitting radionuclides and radium–226 are determined semiannually on the composite samples by gamma-ray spectroscopy.

[1] Data from July and October 1966 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, Calif.

Figure 1. California surface water sampling stations

Discussion

Table 1 shows the monthly average beta radio activity in the suspended-plus-dissolved solids in surface water supplies in California from January through June 1966. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, these results are not presented. No increase in radioactivity level of surface water has been observed. Table 2 shows specific radionuclide concentrations in California surface waters for 1965 through 1966 by stations. Due to its health significance, the analysis of radium–226 in water was begun several years ago. Table 3 presents concentrations of radium in California water supplies for 1964 through 1965.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1965	March 1966
July–December 1965	November 1966

REFERENCE

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Table 1. Gross beta radioactivity in California domestic waters, January-June 1966

Sampling station	Quality	Concentration (pCi/liter)					
		January	February	March	April	May	June
Alturas	Well	[a] 10	ND	NS	[a] 5	NS	NS
Antioch	Treated	ND	ND	[a] 8	ND	ND	ND
Lake Arrowhead	Treated	NS	NS	[a] 5	[a] 3	[a] 5	NS
Berkeley	Treated	39	[a] 3	[a] 24	ND	ND	ND
Clearlake Highlands	Treated	NS	[a] 17	ND	[a] 11	[a] 3	[a] 19
Crescent City	Well	ND	ND	100	[a] 20	[a] 8	[a] 4
Death Valley	Treated	36	15	[a] 9	[a] 19	[a] 35	65
Dos Palos	Treated	[a] 12	[a] 10	ND	[a] 10	[a] 2	ND
El Centro	Treated	ND	ND	ND	40	[a] 13	[a] 1
Eureka	Raw	[a] 3	ND	[a] 2	[a] 20	ND	[a] 3
	Treated	ND	ND	[a] 6	ND	[a] 3	ND
Fort Bragg	Treated	NS	NS	NS	NS	[a] 3	ND
Los Angeles Laboratory	Raw	[a] 16	[a] 17	[a] 17	[a] 24	[a] 23	[a] 7
Marin Municipal Water District	Treated	127	NS	NS	[a] 15	ND	ND
Mariposa	Treated	ND	[a] 2	[a] 5	[a] 1	[a] 3	[a] 13
Metropolitan Water District of Southern California:							
Lake Havasu	Raw	ND	[a] 19	[a] 11	NS	NS	[a] 12
Weymouth Plant	Treated	[a] 15	ND	[a] 18	[a] 34	[a] 8	NS
Lake Millerton	Raw	[a] 5	[a] 8	24	ND	[a] 6	[a] 18
Monterey	Treated	ND	[a] 5	[a] 7	[a] 7	ND	NS
Napa	Treated	ND	ND	[a] 4	[a] 2	ND	8
Needles	Well	[a] 25	[a] 3	[a] 1	[a] 15	[a] 22	[a] 2
North Marin Water District	Treated	[a] 6	[a] 10	[a] 15	[a] 6	[a] 22	NS
	Raw	[a] 9	[a] 16	[a] 9	[a] 3	[a] 6	NS
	Sludge [b]	23	ND	[a] 21	ND	[a] 50	NS
Oroville:							
California Water Service	Treated	[a] 2	ND	[a] 3	ND	ND	ND
Wyandotte Irrigation District	Treated	[a] 6	NS	[a] 3	[a] 1	[a] 9	ND
Pleasanton	Well	[a] 22	[a] 7	ND	[a] 7	ND	ND
Redding	Treated	NS	NS	[a] 10	[a] 1	ND	[a] 18
Sacramento	Treated	NS	ND	[a] 13	[a] 9	[a] 2	[a] 2
Salinas	Well	NS	ND	[a] 13	[a] 12	NS	NS
San Diego	Raw	37	[a] 7	[a] 10	ND	[a] 20	[a] 26
	Treated	[a] 21	[a] 7	[a] 13	[a] 9	[a] 25	[a] 9
San Francisco:							
Water Department	Raw	[a] 10	[a] 12	[a] 9	[a] 14	[a] 11	[a] 2
Alameda, East	Raw	NS	[a] 6	[a] 8	[a] 2	[a] 8	ND
Brightside Weir	Raw	NS	[a] 14	ND	[a] 6	ND	ND
Calaveras Reservoir	Raw	NS	[a] 5	[a] 8	ND	[a] 4	ND
Crystal Springs	Raw	NS	[a] 6	ND	ND	[a] 13	ND
Hetch Hetchy	Raw	ND	[a] 10	ND	[a] 14	[a] 13	ND
San Jose	Raw	ND	ND	ND	ND	[a] 11	NS
San Luis Obispo	Treated	[a] 1	NS	NS	NS	NS	NS
Santa Barbara	Treated	[a] 8	ND	[a] 7	[a] 9	ND	[a] 5
Santa Rosa	Raw	ND	[a] 4	ND	[a] 5	ND	[a] 3
	Well	ND	[a] 5	NS	[a] 9	NS	NS
Tahoe City	Raw	[a] 4	ND	NS	[a] 1	ND	NS
Ukiah	Well	NS	[a] 1	NS	ND	ND	ND
Vallejo:							
Fleming Hill	Raw	[a] 10	[a] 10	[a] 4	ND	ND	ND
	Treated	ND	ND	ND	[a] 7	ND	[a] 15
Swanzy Reservoir	Treated	[a] 8	[a] 5	[a] 18	[a] 11	ND	[a] 1
Yosemite	Treated	[a] 5	[a] 16	[a] 6	[a] 21	ND	ND
Maximum		127	19	100	40	35	65
Minimum		1	1	1	1	2	1

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.
[b] Sludge reported in pCi/g (dry weight).
ND, no detectable activity.
NS, no sample collected.

Table 2. Radionuclide concentrations in composite samples of California surface water, 1965–1966

Sampling station and date	Concentration (pCi/liter)					
	Potassium-40	Manganese-54	Strontium-90	Zirconium-niobium-95	Cesium-137	Cerium-141-Cerium-144
Antioch:						
July-December 1965	[a]2	ND	1	ND	ND	ND
Berkeley:						
July-December 1965	[a]1	ND	1	ND	2	ND
Dos Palos:						
September 1965-February 1966	[a]2	ND	1	ND	ND	ND
El Centro:						
July-December 1965	3	ND	4	ND	1	ND
Fort Bragg:						
January-December 1965	[a]1	1	1	ND	1	1
Metropolitan Water District of Southern California Weymouth Plant:						
July-December 1965	ND	ND	ND	ND	ND	ND
Lake Millerton:						
July-December 1965	[a]2	ND	1	ND	ND	ND
Monterey:						
August 1965-February 1966	[a]1	ND	ND	ND	ND	[a]1
Napa:						
July-December 1965	[a]1	ND	1	ND	ND	ND
Needles:						
July-December 1965	9	1	ND	ND	1	1
North Marin Water District:						
July-December 1965	6	ND	2	ND	ND	ND
Redding:						
July-December 1965	[a]2	ND	ND	ND	ND	ND
Sacramento:						
October 1965-March 1966	[a]2	ND	1	ND	ND	3
San Diego:						
July-December 1965	[a]4	ND	2	<0.1	ND	ND
San Francisco:						
January-December 1965	1	ND	1	ND	ND	ND
Santa Barbara:						
August 1965-February 1966	3	ND	1	ND	ND	1
Santa Rosa:						
July-December 1965	4	ND	1	ND	ND	ND
Tahoe City:						
July-December 1965	[a]4	ND	1	[a]1	1	ND
Vallejo:						
July-December 1965	2	ND	1	ND	ND	ND
Yosemite:						
July-December 1965	[a]3	ND	1	[a]1	ND	ND

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
ND—no detectable activity

Table 3. Radium-226 in California domestic water, 1964–1965

Sampling station	Sampling date	Concentration (pCi/liter)	Sampling station	Sampling date	Concentration (pCi/liter)
Antioch	4/15/65	0.046	Oroville:		
Berkeley	1/1/65	.000	California Water Service	1/16/65	0.010
	1/13/65	.006		7/1/65	.023
	4/2/65	.016	Wyandotte Irrigation District	1/16/65	.040
Crescent City	10/1/64	.002		7/1/65	.006
Dos Palos	7/1/64	.003	Redding	2/15/65	.022
	12/2/64	.045		10/1/65	.019
	7/1/65	.001	Sacramento	9/16/64	.003
El Centro	1/3/64	.050		10/1/64	.010
	7/18/64	.090		8/1/65	.008
	2/1/65	.140	San Diego	8/19/64	.200
	10/1/65	.110		3/3/65	.160
Eureka	4/1/64	.020		8/31/65	.317
	10/1/64	.012	San Jose	4/1/65	.022
Fort Bragg	7/1/65	.020	Santa Barbara	11/29/64	.040
Marin Municipal Water District	6/16/64	.000		12/15/64	.070
Metropolitan Water District of Southern California	10/1/64	.200		6/1/65	.033
Lake Millerton	5/1/64	.010	Santa Rosa	10/1/64	.008
	11/1/64	.020		3/2/65	.010
	9/16/65	.008	Scotia	11/9/64	.020
Monterey	5/1/64	.020	Tahoe City	11/30/64	.010
	11/16/64	.020		4/2/65	.010
	4/16/65	.033	Ukiah	4/1/64	.010
Napa	9/1/64	.010	Yosemite	7/1/64	.010
	3/1/65	.002		4/1/65	.012
Needles	10/1/65	.013			
North Marin Water District	10/1/64	.007			
	4/1/65	.007			
	10/1/65	.005			

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data.* In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period reported	Last presented
HASL Fallout Network	July–December 1965	September 1966
HASL 80th Meridian Network	Calendar Year 1965	January 1967

1. Radiation Surveillance Network February 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples or airborne particles and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during February 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Airborne gross beta radioactivity decreased appreciably during February. The two samples in table 2 exceeded 1.0 pCi/m^3.

Fresh fission products were identified by gamma-ray spectroscopy on 107 out of 286 samples counted.

Deposition by precipitation also decreased in February. Forty samples contained more than minimum reporting levels of gross beta radioactivity. The highest concentration was 1,900 pCi/liter collected at Barre, Vt., on February 14, and the highest total deposition for the month was 7.0 nCi/m^2, also at Barre, Vt.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1967

Station location		Number of samples		Air surveillance, gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	28	10	0.37	0.05	0.20	Nov 66	135	<27
Alaska:	Adak	28	----	.51	.02	.15	Jun 67	[c]	
	Anchorage	14	5	.46	.14	.25	Dec 66	[c]	
	Attu Island	19	----	.14	.00	.07	Jul 66	[c]	
	Fairbanks	7	3	.09	.05	.07	Jan 67	4	< 1
	Juneau	16	15	.13	.00	.06	Apr 67	212	<42
	Kodiak	10	----	.19	.07	.11	May 67	[c]	
	Nome	[b]	----	----	----	----	Sep 66	[c]	
	Pt. Barrow	19	----	.48	.07	.18	Aug 66	[c]	
	St. Paul Island	[b]	----	----	----	----	Oct 66	[c]	
Ariz:	Phoenix	25	----	.86	.20	.46	Apr 67	[c]	
Ark:	Little Rock	26	3	.46	.11	.21	Dec 66	54	<11
Calif	Berkeley	17	1	.46	.09	.21	May 67	9	< 2
	Los Angeles	18	1	1.08	.06	.34	Sep 66	2	< 1
C.Z:	Ancon	14	----	.11	.02	.05	May 67	[c]	
Colo:	Denver	28	2	.67	.14	.27	May 67	3	< 1
Conn:	Hartford	27	8	.36	.06	.19	Apr 67	33	< 7
Del:	Dover	12	----	.32	.07	.16	Nov 66	[c]	
D.C:	Washington	21	5	.28	.07	.16	Aug 66	35	< 7
Fla:	Jacksonville	27	7	.69	.04	.21	Dec 66	147	<29
	Miami	27	4	.46	.04	.21	Apr 67	34	< 7
Ga:	Atlanta	28	5	.46	.06	.22	Oct 66	108	<22
Guam:	Agana	27	----	.23	.00	.04	Nov 66	[c]	
Hawaii:	Honolulu	27	4	.30	.01	.06	Jul 66	115	<23
Idaho:	Boise	28	5	2.03	.04	.25	Jul 66	16	< 3
Ill:	Springfield	23	3	.27	.06	.16	Aug 66	26	< 5
Ind:	Indianapolis	26	6	.34	.10	.19	Oct 66	42	< 8
Iowa:	Iowa City	28	7	.40	.06	.18	May 67	20	< 6
Kans:	Topeka	28	2	.29	.10	.18	Dec 66	1	< 1
Ky:	Frankfort	27	5	.46	.10	.20	Aug 66	35	< 7
La:	New Orleans	27	7	.63	.04	.26	Aug 66	191	<39
Maine:	Augusta	28	9	.33	.08	.18	Sep 66	106	<22
	Presque Isle	20	----	.28	.08	.14	May 67	[c]	
Md:	Baltimore	18	4	.32	.06	.19	Apr 67	31	< 6
	Rockville	15	2	.33	.08	.16	Jul 66	41	< 8
Mass:	Lawrence	28	6	.43	.06	.21	Nov 66	58	<12
	Winchester	16	10	.42	.07	.19	Jun 67	71	<15
Mich:	Lansing	28	----	.27	.06	.16	Jul 66	[c]	
Minn:	Minneapolis	16	8	.26	.07	.14	Nov 66	14	< 3
Miss:	Jackson	28	7	.28	.02	.17	Sep 66	84	<17
Mo:	Jefferson City	28	4	.36	.07	.18	Oct 66	37	< 7
Mont:	Helena	26	5	.55	.06	.22	Jun 67	15	< 3
Nebr:	Lincoln	20	----	.41	.03	.11	Oct 66	[c]	
Nev:	Las Vegas	23	----	.74	.17	.37	Jan 67	[c]	
N.H:	Concord	19	----	.36	.06	.22	Aug 66	[c]	
N.J:	Trenton	27	6	.31	.06	.16	Sep 66	14	< 3
N. Mex:	Santa Fe	27	4	.47	.10	.25	Jun 67	17	< 4
N.Y:	Albany	18	9	.38	.11	.21	Oct 66	32	< 6
	Buffalo	27	----	.23	.07	.14	May 67	[c]	
	New York City	27	----	.37	.08	.19	Jun 67	[c]	
N.C:	Gastonia	28	9	.37	.01	.21	May 67	79	<18
N. Dak:	Bismark	28	7	.24	.07	.12	Aug 66	27	< 5
Ohio:	Cincinnati	12	----	.28	.11	.20	Nov 66	[c]	
	Columbus	26	7	.59	.12	.25	Sep 66	37	< 8
	Painesville	28	9	.32	.07	.18	Apr 67	54	<15
Okla:	Oklahoma City	27	4	.42	.06	.14	Jul 66	5	< 1
	Ponca City	27	3	.16	.04	.07	Apr 67	22	< 5
Ore:	Portland	24	9	.31	.01	.13	Oct 66	44	< 9
Pa:	Harrisburg	28	----	.29	.06	.13	Oct 66	[c]	
P.R:	San Juan	23	3	.17	.03	.09	Sep 66	69	<14
R.I:	Providence	27	7	.35	.03	.16	Jul 66	25	< 5
S.C:	Columbia	26	8	.31	.03	.17	Jun 67	96	<19
S. Dak:	Pierre	28	----	.23	.08	.12	Apr 67	[c]	
Tenn:	Nashville	28	8	.33	.07	.17	Jul 66	48	<10
Tex:	Austin	28	4	.28	.07	.18	Nov 66	30	< 6
	El Paso	25	2	.57	.14	.26	Aug 66	2	< 1
Utah:	Salt Lake City	27	2	.79	.06	.32	Sep 66	20	< 5
Vt:	Barre	27	9	.33	.07	.19	Dec 66	29	<11
Va:	Richmond	25	4	.29	.05	.16	Dec 66	33	< 7
Wash:	Seattle	25	9	.32	.00	.09	Dec 66	33	< 8
	Spokane	28	2	.35	.04	.14	Nov 66	2	< 1
W. Va:	Charleston	28	9	.41	.08	.17	Jun 67	60	<12
Wis:	Madison	27	6	.21	.04	.12	Dec 66	49	<10
Wyo.	Cheyenne	27	3	.48	.11	.22	Jan 67	10	< 2
Network summary		1,718	301	2.03	0.00	0.17	----	47	<10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of 0.005 pCi/m³ or less are reported and used in averaging as 0.00 pCi/m³.
[b] No precipitation sample collected.
[c] No report received.

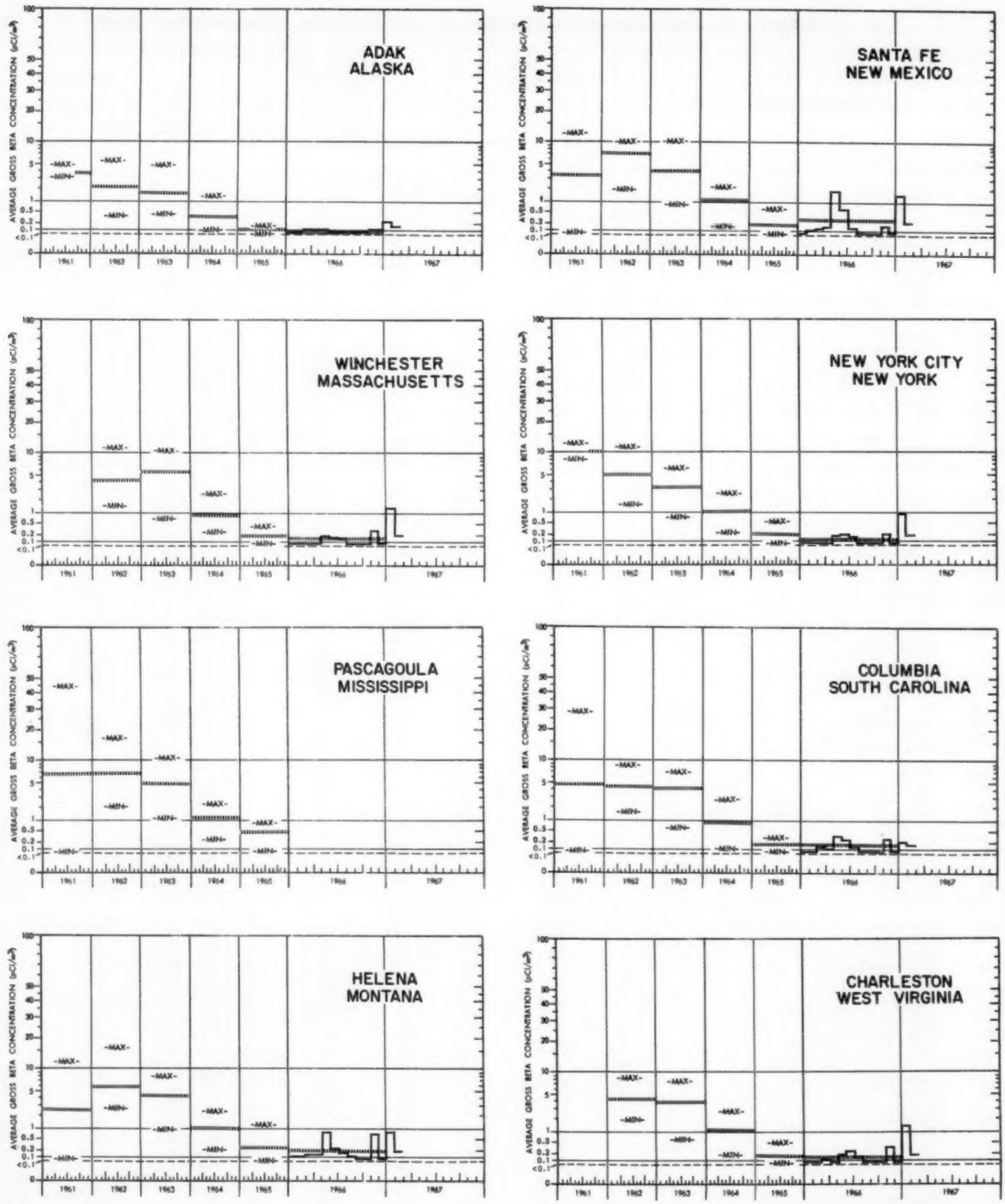

Figure 2. Monthly and yearly profiles of gross beta radioactivity in air—Radiation Surveillance Network 1961–February 1967

Table 2. RSN stations with gross beta radioactivity in particulates in excess of 1 pCi/m³

Location	Date	Beta radio activity (pCi/m³)
Calif: Los Angeles	2/9/67	1.08
Idaho: Boise	2/25/67	2.03

2. Canadian Air and Precipitation Monitoring Program, February 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for February 1967 are presented in table 3.

[1] Prepared from information and data in the March 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

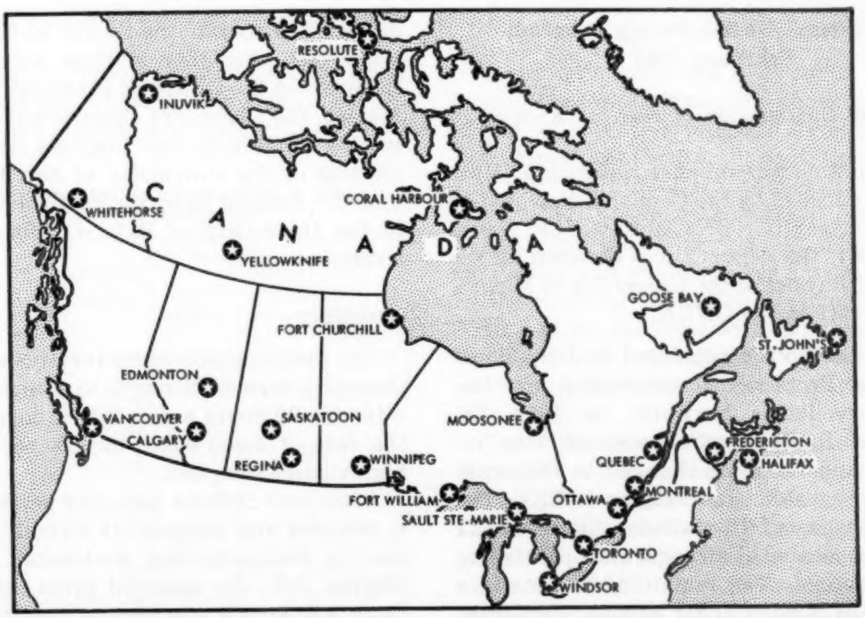

Figure 3. Canadian air and precipitation sampling stations

Table 3. Canadian gross beta radioactivity in surface air and precipitation, February 1967

Station	Number of samples	Air surveillance radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	28	0.8	0.1	0.3	98	1.0
Coral Harbour	27	.4	.0	.2	([a])	1.5
Edmonton	28	.4	.1	.2	71	1.0
Ft. Churchill	28	.4	.0	.2	132	1.1
Ft. William	28	.5	.1	.1	15	.3
Fredericton	28	.3	.1	.2	14	1.8
Goose Bay	27	.3	.0	.2	78	4.1
Halifax	27	.4	.1	.2	15	1.9
Inuvik	28	.3	.1	.2	88	.8
Montreal	28	.4	.1	.2	NS	NS
Moosonee	27	.3	.1	.2	20	.6
Ottawa	28	.4	.1	.2	19	1.1
Quebec	28	.3	.1	.2	34	2.9
Regina	28	.3	.1	.2	69	.8
Resolute	28	.5	.1	.2	([a])	.1
St. John's Nfld	26	.3	.0	.1	NS	NS
Saskatoon	28	.3	.1	.2	68	.7
Sault Ste. Marie	27	.5	.0	.2	18	1.2
Toronto	28	.4	.1	.2	47	2.7
Vancouver	28	.4	.0	.1	50	4.6
Whitehorse	28	.3	.0	.2	35	1.6
Windsor	28	.6	.1	.2	50	1.9
Winnipeg	28	.4	.1	.2	78	.7
Yellowknife	28	.4	.0	.2	42	.6
Network summary	------	0.4	0.1	0.2	52	1.5

[a] Trace precipitation
NS, no sample

3. Mexican Air Monitoring Program February 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Galfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja, California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron.

Figure 4. Mexican air sampling locations

The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (7).

The maximum, minimum, and average gross beta radioactivity in surface air during February 1967 are presented in table 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, February 1967

Station	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	18	0.3	0.1	0.2
Chihuahua	7	.6	.1	.2
Ciudad Juáres	10	.4	< .1	.3
Ensenada	9	.6	.1	.3
Guadalajara	NS	----------	----------	----------
Guaymas	NS	----------	----------	----------
La Paz	3	.9	.2	----------
Matamoros	NS	----------	----------	----------
Mazatlán	15	.6	.1	.3
Mérida	10	.4	.1	.2
México, D.F.	12	.3	< .1	.1
Nuevo Laredo	1	----------	----------	----------
San Luis Potosí	NS	----------	----------	----------
Tampico	NS	----------	----------	----------
Torreón	22	.5	.1	.2
Veracruz	3	.1	< .1	----------

NS, no sample collected, station temporarily shutdown.

4. Pan American Air Sampling Program February 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station positions are shown in figure 5.

The February 1967 air monitoring results from the participating countries are given in table 5. The most active sample was collected at Caracas, Venezuela on February 17th, and measured 0.27 pCi/m^3 when counted on February 24, 1967. No fresh fission products were identified in PAHO air samples during February.

Figure 5. Pan American Air Sampling Program stations

Table 5. PAHO gross beta radioactivity in surface air February 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina, Buenos Aires	17	0.18	0.03	0.09
Bolivia, La Paz	14	.06	.01	.02
Chile, Santiago	28	.14	.03	.08
Colombia, Bogota	21	.08	.01	.04
Ecuador, Guayaquil	21	.04	.00	.02
Jamaica, Kingston	16	.14	.02	.06
Peru, Lima	23	.09	.04	.06
Venezuela, Caracas	14	.27	.03	.08
West Indies, Trinidad	18	.10	.02	.06
Pan American summary	172	0.27	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of 0.005 or less are reported and used in averaging as 0.00 pCi/m³.

REFERENCES

(1) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. National Center for Radiological Health, Public Health Service, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Sequridad Radiológica (en prensa 1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactivity materials from AEC installations are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Brookhaven National Laboratory and the Lawrence Radiation Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Brookhaven National Laboratory July–December and annual summary 1966 [2]

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: 1) by discharge of coolant air from the graphite research reactor, 2) by radiation from an ecology forest gamma-ray source, and 3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

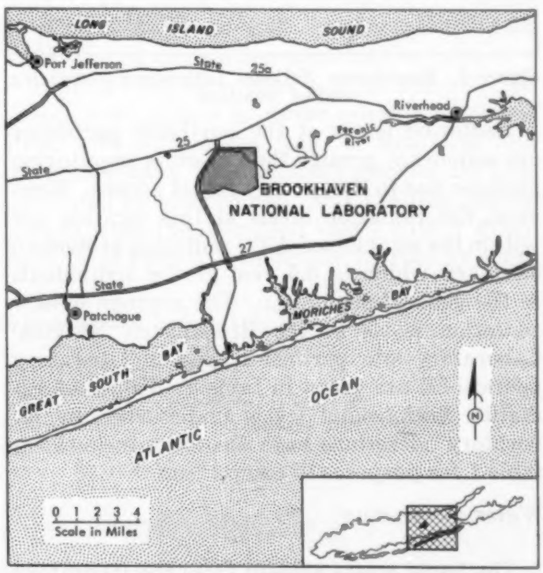

Figure 1. Brookhaven National Laboratory and surrounding area

[2] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the Second Half of 1966," Associated Universities, Inc., Upton, N.Y.

Area monitoring

The radioactivity in the discharge coolant air is almost entirely due to argon–41, a beta-gamma emitter. Monitoring for argon–41 is performed by continuously measuring the gamma-ray exposure rate in milliroentgens per week (mR/wk), rather than the concentration in air, at four stations located along the site perimeter (figure 2). These same stations monitor radioactivity resulting from a 10,000 curie cesium–137 gamma-ray source, situated in an ecology forest, about 800-meters equidistant from the north and east boundaries of the BNL.

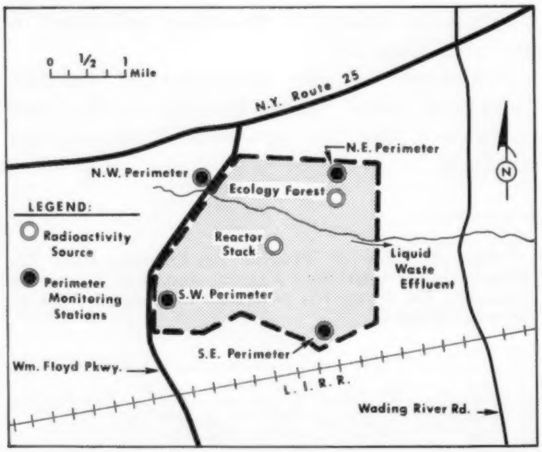

Figure 2. Brookhaven National Laboratory monitoring station locations

Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to the ecology forest source. However, the radiation levels at this location are within the established AEC radiation protection standard which is 0.5 rem/yr for individuals in the general population. The average weekly radiation levels at the Brookhaven National Laboratory site perimeter, due to laboratory operations, are given in table 1. Values of radiation background levels undisturbed by laboratory operations have also been included in table 1 for purposes of comparison.

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the BNL site. The average concentration and total amount of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 2 for July to December and calendar year 1966.

Table 1. External gamma radioactivity at BNL site perimeter July-December and calendar year 1966

Period	Average exposure rates (mR/wk)			
	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast perimeter
Second half 1966	0.13	0.23	0.19	2.66
July	.08	.10	.19	3.66
August	.10	.17	.22	3.64
September	.21	.57	.14	2.50
October	.14	.14	.57	2.03
November	.06	.08	.02	2.60
December	.17	.24	.07	1.76
First half 1966	.18	.20	.46	2.32
Calendar year 1966	.16	.22	.33	2.49
Undisturbed background, calendar year 1966	1.95	1.78	1.92	1.98

Analysis of composite samples of the effluent has shown that, on the average, no more than 20 percent of the radioactivity consists of strontium–90 and that no appreciable amounts of radioactive iodine or radium and other bone-seeking radionuclides are present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 3,000 pCi/liter.

Table 2. Gross beta radioactivity in liquid waste effluent at BNL site boundary, July-December and calendar year 1966

Period	Average radioactivity (pCi/liter)	Total radioactivity discharged (mCi)
Second half 1966	26	14.8
July	41	3.8
August	28	3.3
September	22	2.0
October	21	2.3
November	23	1.8
December	23	1.6
First half 1966	38	20.6
Calendar year 1966	32	35.4

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966
January–June 1966	December 1966

2. Lawrence Radiation Laboratory January–June 1966 [3]

University of California
Berkeley, California

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (figure 3). Winds are generally westerly; annual rainfall is 23 inches, most of which usually falls during the period from November through April. Technical facilities include a 6.3 BeV proton accelerator (Bevatron), a 700-MeV cyclotron, a 10-MeV linear accelerator, an 88-inch cyclotron, and associated chemistry and physics laboratories.

The environmental monitoring program includes sampling for radionuclides in the atmosphere, surface and ground waters, sewage, rain, and dry depositions.

Three types of atmospheric samples are taken: laboratory exhaust duct samples, local area samples and perimeter samples. One hundred eleven exhaust air ducts with potential for releasing radioactive contaminants are sampled continuously at a flow rate of 1 liter per minute. The one-inch-diameter filters are changed weekly and counted for beta radioactivity by an end-window Geiger-Mueller tube and for alpha radioactivity by a thin-window proportional counter. Continuous local area and perimeter air samples are taken at scattered locations on the laboratory site and at the property line, respectively. The samples are obtained on 4- by 9-inch HV–70 filter papers at 4 cubic feet per minute. The filters are collected weekly and counted for alpha radioactivity by a thin-window proportional counter and for beta radioactivity by a 30 mg/cm^2-window Geiger-Mueller tube. The levels of radioactivity observed in each type of sample are presented in table 3.

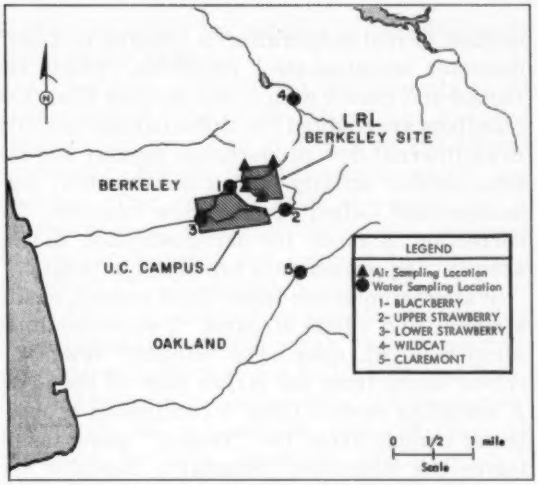

Figure 3. Environmental sampling locations at the Berkeley site

Rain and dry deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Precipitation samples are concentrated by evaporation. Dry samples are removed from the collection vessel with a dilute nitric acid rinse and then concentrated by evap-

[3] Summarized from "Results of Environmental Radioactivity Sampling Program, January–June 1966," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

Table 3. Atmospheric monitoring, LRL Berkeley site, January-June 1966

Sampling locations (number of locations)	Number of samples	Concentration [a] (pCi/m^3)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Exhaust ducts (111)	4,327	<0.10	(b)	<2.3	(b)
Local area (10)	230	< .005	<0.005	<0.15	0.55
Perimeter (4)	100	< .005	.009	< .15	.47

[a] Limits of detectability for individual samples (pCi/m^3):
Exhaust ducts 0.10 alpha 2.3 beta
Local area and perimeter 0.005 alpha 0.15 beta
[b] No reported data.

oration. Final evaporation is effected in 2-inch diameter stainless-steel planchets, which are flamed and coated with a thin lacquer film. The planchets are counted for alpha-particle activity in an internal-flow proportional counter and for beta-particle activity with a thin-window, low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Deposition data are given in table 4.

Water samples are taken from sewers, onsite streams, and offsite streams. Two sewer lines serve the LRL area. The "Hearst" sewer receives waste from the larger part of the area. A sampling system takes a continuous proportional sample from the "Hearst" sewer as it leaves the laboratory boundary. Samples are also taken of waste feeding into the Hearst sewer from buildings 70, 70A, and 71. The "Strawberry" sewer receives waste from the southeast part of the laboratory site. A monitoring station takes a continuous proportional sample from this sewer. Continuous samples are also taken from the acid waste systems in building 74, which is the most likely contributor of radioactivity to the "Strawberry" sewer line. The concentrations of radioactive wastes in sewage, shown in table 5, are either those observed directly in samples from the sewer line or those calculated from samples taken from contributing waste streams, whichever was the higher value. Strawberry and Blackberry Creeks comprise the laboratory's storm drainage. These are sampled weekly at three locations. Two other nearby offsite streams are also sampled weekly. All water samples are handled in the same manner as rain samples. The results from the water sampling program are presented in table 5.

Table 4. Total deposition, LRL Berkeley site, January-June 1 966

Sampling locations (number of locations)	Number of samples	Deposition (nCi/m^2)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum[a]	Average	Maximum[a]
Local area (10)	58	0.02	0.10	0.81	2.86
Perimeter (4)	24	.02	.07	.81	2.20

[a] Maximum deposition at a single location for the 6-month period.

Table 5. Water monitoring, LRL Berkeley site, January-June 1966

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Sewage:					
Hearst sewer	25	1.32	23.6	40.3	57.3
Strawberry sewer	26	0.45	3.6	40.0	296.4
Tap water	26	0.02	0.4	3.0	7.9
Surface water:					
Onsite streams	93	1.17	10.7	7.7	72.7
Offsite streams	50	0.50	2.6	3.1	26.0

Livermore site

The Livermore site of LRL (figure 4) is located about 50 miles southeast of San Francisco, Calif. Annual precipitation in the Livermore Valley is about 14 inches; prevailing winds are from the west with frequent nocturnal inversions. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

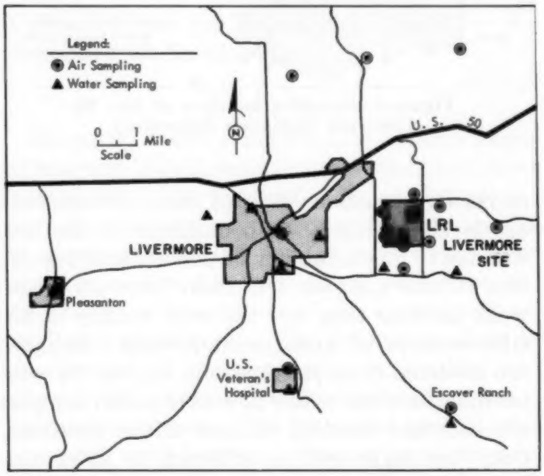

Figure 4. Environmental sampling locations at the Livermore site

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products, and since January of this year, milk. The milk samples are obtained from two dairies in the Livermore Valley and one in a neighboring valley, which is used as a check. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas-flow proportional detectors for both alpha and beta-particle activity measurements. Alpha-particle activity in 401 air samples collected from 15 sampling locations averaged 0.0010 pCi/m^3, while beta-particle activity averaged 0.060 pCi/m^3. The applicable AEC radiation protection standards are 0.040 pCi/m^3 for alpha-particle emitters and 1 pCi/m^3 for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with fluoroglass dosimeters located at nine points on the site perimeter and at two nearby ranches. The dosimeters, which have a detection limit of 50 mR, were measured after 6-months of exposure. No dosimeter indicated a detectable amount of external radiation for the period. The average dose rate at the laboratory perimeter, based upon these measurements, was less than 0.01 mR/hr.

Domestic water samples are collected monthly from nine nearby sources. No water sample showed alpha radioactivity above the limit of sensitivity (5.0 pCi/liter) for the automatic gas-flow proportional detection system. The beta radioactivity ranged from less than the limit of sensitivity (1.8 pCi/liter) to 13 pCi/liter. The average alpha and beta radioactivity in water samples was less than their respective AEC radiation protection standards of 10 and 100 pCi/liter.

Samples are collected every Monday, Wednesday, and Friday, at the sewer line leaving the southwest project boundary, where it connects with the Livermore domestic sewerage system. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that the liquid effluent from the laboratory is

not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner). Radioactivity levels in the raw sewage, oxidation ponds, and dried sludge are summarized in table 6.

Table 6. Environmental sampling, LRL Livermore site January-June 1966

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Raw sewage (pCi/liter)	6	77
Oxidation ponds (pCi/liter)	7	18
Dried sludge (pCi/g)	42	15

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha-particle activity fluctuated from less than the limit of sensitivity (1.5 pCi/g) to 9 pCi/g. The beta-particle activity fluctuated from less than the limit of sensitivity (3.5 pCi/g) to 23 pCi/g. The average alpha radioactivity was 2.8 pCi/g and the average beta radioactivity was 7.0 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 14 pCi/liter of cesium–137 and 6 pCi/liter of cerium–141–144, for the two Livermore dairies. These levels closely correspond to those for a dairy in a neighboring valley about 25 miles from Livermore. The June milk samples showed slight increases due to the Chinese nuclear test in May.

Site 300

Site 300 (figure 5) is located in a very sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed

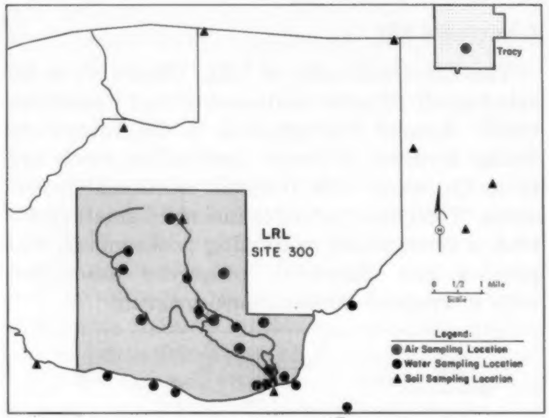

Figure 5. Sampling locations at Site 300 Lawrence Radiation Laboratory

on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Samples are collected from streams only during the winter months when water flow exists. Soil samples are collected monthly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the laboratory in Livermore. The average radioactivity levels in samples collected are summarized in table 7.

Table 7. Environmental sampling, LRL Site 300 January-June 1966

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Air (pCi/m³)	0.001	0.058
Water (pCi/liter)	<5.0	4.4
Soil (pCi/g)	7	7

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1965	May 1966
July–December 1965	November 1966

SECTION V. TECHNICAL NOTES

Full Scale Strontium-90 Removal System for Fluid Milk

National Center for Radiological Health
Public Health Service

Recently, it was reported (*1–2*) that 5 years of research in the laboratory and pilot plant have culminated in the successful design and operation of a full-scale commercial system capable of processing 100,000 lbs. of fluid whole milk per 8-hour day for removal of strontium–90. An extensive description of the system will be published shortly (*3*). The automated plant is constructed of stainless steel and other approved dairy industry materials meeting sanitary requirements. The full-scale process employs the fixed-bed ion-exchange principle and is based on results from a combined effort of the U.S. Department of Health, Education, and Welfare, Public Health Service, the U.S. Department of Agriculture, Agriculture Research Service, and the U.S. Atomic Energy Commission, at a pilot plant in the Agricultural Research Center, Beltsville, Md., and laboratory scale research performed at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. The process involves acidification of raw milk to pH 5.35, passage through a fixed resin bed and readjustment of the milk to pH 6.60. The design, fabrication, operation, and evaluation of the full-scale process was performed under a government contract with the Producers Creamery Company of Springfield, Mo.

Several experimental runs were made using the commercial scale equipment during the period May 1964 through February 1965. The pertinent data for these tests are given in table 1. Nine test runs of 100,000 lbs. each (the February 25, 1965 run consisted of two 100,000 lb. runs) have demonstrated that an average of 92.1 percent of the strontium–90 can be removed from fluid milk. No unusual processing

Table 1. Results of commercial scale treatment of fluid milk for removal of strontium-90 by fixed-bed ion exchange

Date	Type of milk processed	Total weight of milk (lb)	Elapsed time (hr)	Average rate of flow (lb/hr)	Concentration of strontium-90 (pCi/liter)		Removal efficiency (percent)
					Raw milk	Processed milk	
5/22/64	Skim	99,340	8.03	12,400	42.2	2.9	93.1
6/24/64	Whole	103,880	12.17	8,865	36.0	1.1	96.9
8/20/64	Skim	103,540	8.83	11,520	32.9	1.8	94.5
9/2/64	Skim	104,260	8.55	12,650	43.7	2.4	94.5
9/16/64	Whole	99,840	8.75	14,265	31.0	2.1	93.2
10/14/64	Whole	103,000	11.08	12,000	25.6	2.7	89.5
2/21/65	Whole	104,800	13.22	11,685	31.7	4.4	86.1
2/25/65	Whole	202,160	15.13	13,359	32.6	3.7	88.7

problems were encountered during these runs.

Flavor scores for six of these runs, comparing control milk and treated milk are given in table 2. At a seminar conducted on February 25, 1965, milk processed on February 21 was taste-tested for acceptability of the treated product from a flavor point of view, using health, agriculture, and milk industry representatives as the taste panel. Of the 54 panelists, 9 persons could detect no difference between the treated and commercially-marketed milk, 19 persons preferred the treated milk, and 26 persons preferred the market milk.

Table 2. Average taste panel scores for whole milk[a] (samples 3 days old)

Date	Control sample	Experimental sample
6/24/64	37.4	35.8
9/16/64	38.4	37.4
10/14/64	38.6	37.8
2/21/65	37.0	36.9
2/25/65 (first run)	36.9	35.4
2/25/65 (second run)	37.1	35.2

[a] American Dairy Science standard flavor test; perfect score is 40; acceptable score for pasteurized commercial market milk is 35.

The commercial scale process was shown to be a technically acceptable method of safeguarding the milk consumer against intake of hazardous quantities of strontium–90. Its feasibility for use by the milk industry in the event of an emergency has been demonstrated. The staff of most milk processing plants are capable of properly operating the equipment following several hours of technical training. Currently, an economic evaluation of the process is underway. However, prior to the installation of the equipment for commercial use, additional evaluation and clearance of the equipment may be necessary.

REFERENCES

(1) FOOKS, J. H., J. G. TERRILL, JR., B. H. HEINEMANN, E. J. BALDI, and H. E. WALTER. Evaluation of the full-scale strontium removal system for fluid milk. Health Physics 13:279–286 (March 1967).

(2) BALES, R. E. and J. L. S. HICKEY. Commercial processing of milk for concurrent removal of cationic and anionic radionuclides. Proceedings of a seminar July 12–15, 1966, on radioisotopes and radiation in dairy science and technology, IAEA (November 1966).

(3) PROCEEDINGS OF A SEMINAR, LEBANON, MO., FEBRUARY 1965. Full-scale system for removal of radiostrontium from milk. A cooperative research investigation supported jointly by the USDHEW, DRH, and USDA, Agricultural Research Service, Eastern Utilization, Research and Development (In press).

Reported Nuclear Detonations, May 1967

During May 1967 the U.S. Atomic Energy Commission announced four underground nuclear tests conducted at its Nevada Test Site. The tests of May 10 and May 26 were low-intermediate yield (20 to 200 kilotons TNT equivalent) and the tests of May 20 and 23 were intermediate yield (200 kilotons to 1 megaton TNT equivalent).

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

FALLOUT FROM THE THIRD CHINESE NUCLEAR TEST—MAY 9, 1966. *R. D. Grundy* and *D. R. Snavely*. *Radiological Health Data and Reports*, *Vol. 8*, *June 1967*, pp. 301–316.

Fresh fission product debris was detected in the United States in selected environmental media following the third Chinese atmospheric nuclear detonation of May 9, 1966. Peak concentrations in air, precipitation deposition, bovine thyroids, and milk, occurred in the Central and Southern States. Levels of iodine–131 in milk as observed by 4 State sampling programs and 18 Public Health Pasteurized Milk Network stations provides the basis for calculating iodin–131 pasture weathering half-time of 4 to 58 days. A peak iodine–131 milk concentration of 920 pCi/liter was observed in Arkansas on May 21, 1966. The resultant cumulative iodine–131 intake at this location based upon an assumed daily milk consumption of 1 liter, was calculated to correspond to 1.7 percent of the Radiation Protective Action Guide as established by the Federal Radiation Council.

KEY WORDS: air, beta radioactivity, bovine thyroid network, fallout, iodine–131, mainland China, milk, nuclear test, pasteurized milk network, pasture half-time, precipitation.

ORDER BLANK FOR RHD&R

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check ☐ for this subscription. ($5.00 a year; $1.50 additional for foreign mailing.)

Please address RHD&R as follows. ______________________________

____

____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1965

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $5.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

June 1967

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' ĭ
10^{-2}	centi	c	sĕn' tĭ
10^{-3}	milli	m	mĭl' ĭ
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/m^2)
MeV	million (mega) electron volts.	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose.	100 ergs per gram

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐; tear off this label and return it to the above address. Your name will then be promptly removed from the appropriate mailing list.